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Control of traffic movements at an important marshalling yard on the Belgian State Railways (1),

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INTRODUCTION.

The Belgian State Railways have adopted, commencing the 3 November 1924, a system of controlling the whole of the traffic movements at the important sorting sidings at Schaerbeek-Formation.

This station, which is being completely reorganised, consists of a series of scattered sidings which it has been necessary to use indiscriminately for receiving incoming trains, for sorting and for marshalling out-going trains. It is, moreover, situated at a very important railway centre surrounded by junctions of such a nature that a freight train held up at

(1) Translated from the French.

certain home signals may completely stop traffic movements on the principal lines in the vicinity (fig. 1).

At normal times, each set of sidings is worked independently, but if any set of sidings tends to become congested, part

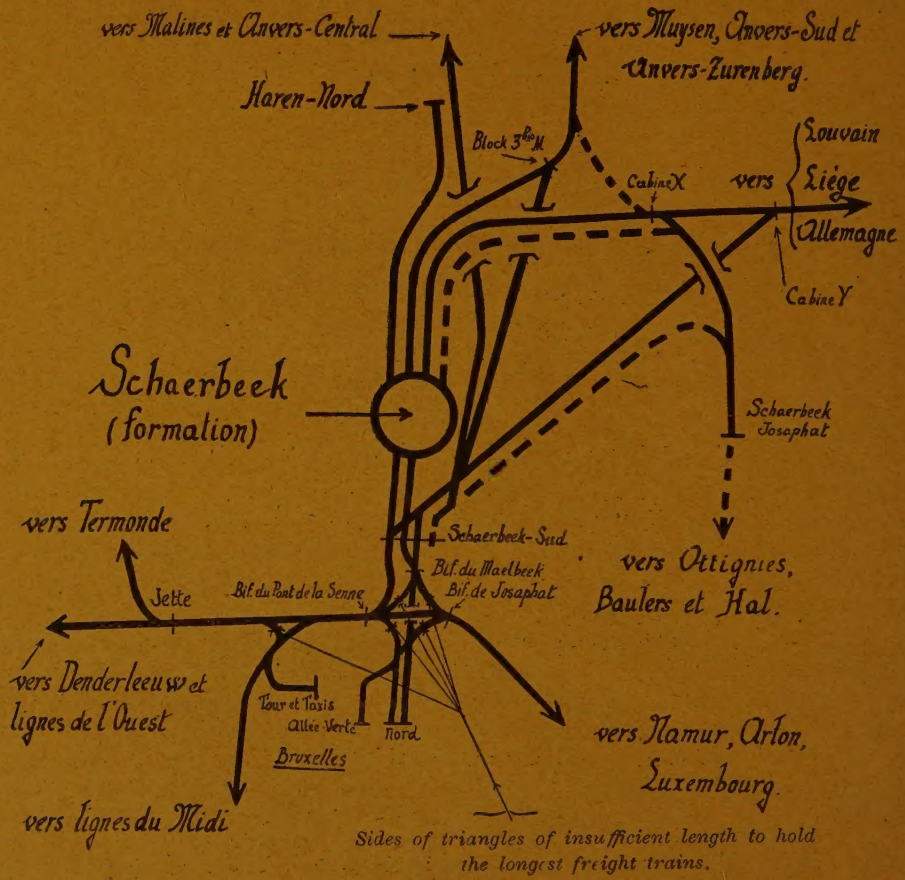


Fig. 1. — Lines around Schaerbeek-Formation.

of the traffic which is normally dealt with by the congested siding may be diverted to other sets of sidings.

Moreover, all the lines radiating from Schaerbeek-Formation are organised on the « control or dispatching system ». In order that the intervention of the « controllers » may be efficacious, it is necessary that they should be in touch with an authority fully conversant and well informed with all the details of train movements at Schaerbeek-Formation.

For this reason, it has been recognised as necessary to institute a central office to control the entire movements in the station, to co-ordinate the work at the various sorting sidings, to take decisions that will best serve the interests of the

system as a whole, and to collect all information which may be used in determining the amount of traffic to be catered for at any given moment and the best means of providing for this.

In this way a scheme has arisen for instituting at Schaerbeek-Formation a new system similar to the « control or dispatching system » operated on the same principles, by appointing a Controller, whose *special* duties are the *control* of all local problems of the traffic department, having at his disposal a *perfected telephone system.*

In order to fully understand the administrative organisation of the Controller's office, it is necessary to give some details of the lay-out of the station and on its method of operation.

CHAPTER I.

Details of the lay-out and method of working at Schaerbeek-Formation Station.

§ 1. — Present day situation.

Up to 1911, Schaerbeek-Formation Station consisted of sidings J and K and a group of dead-end roads in a fan-shape formation (fig. 2).

At that time, by reason of increased industrial and commercial activity, the limit of the capacity of these sidings was reached, and it was necessary to add, in accordance with the available space, groups of sidings M and U. In 1913, 12 of the dead-end roads were lengthened to form siding V with an exit at both ends.

These sidings were not used exclusively for one class of operation such as receiving in-coming trains, sorting and marshalling out-going trains. In each set of sidings the whole of the operations for any given traffic was carried out, and this was not departed from except when it was necessary to assist a set of sidings which were becoming congested.

The group of sidings V and the dead-end roads (31 roads) were used for traffic towards the Borinage and the Centre, towards the North and West of the country. In these sidings were also concentrated wagons used for local services (Schaerbeek and Haren-North goods yards and various private sidings, carriage and wagon shops and Brussels North engine shed).

Groups of sidings J and K (17 roads) dealt with the greater part of the traffic towards the Port of Antwerp, Charleroi and Tournaisis districts and the Western Ceinture Railway of Brussels.

In group M (17 roads) was concentrated the traffic for the East of the country and for Schaerbeek (Josaphat).

Group U (17 roads) was used for traffic to the South-East (Namur-Arlon-Luxemburg line and branches) and for traffic proceeding from or going to the engine shed at Schaerbeek or in connection with the alterations to the yards.

Moreover, 16 roads were used for accommodating spare coaching stock for use on troop trains or for special or seasonal passenger trains. This group of sidings is known as « Japan » and will be incorporated in the future sidings of the new lay-out.

As regards the siding with 9 roads marked « Triage » (« Sorting sidings ») extending to the North of groups M and U

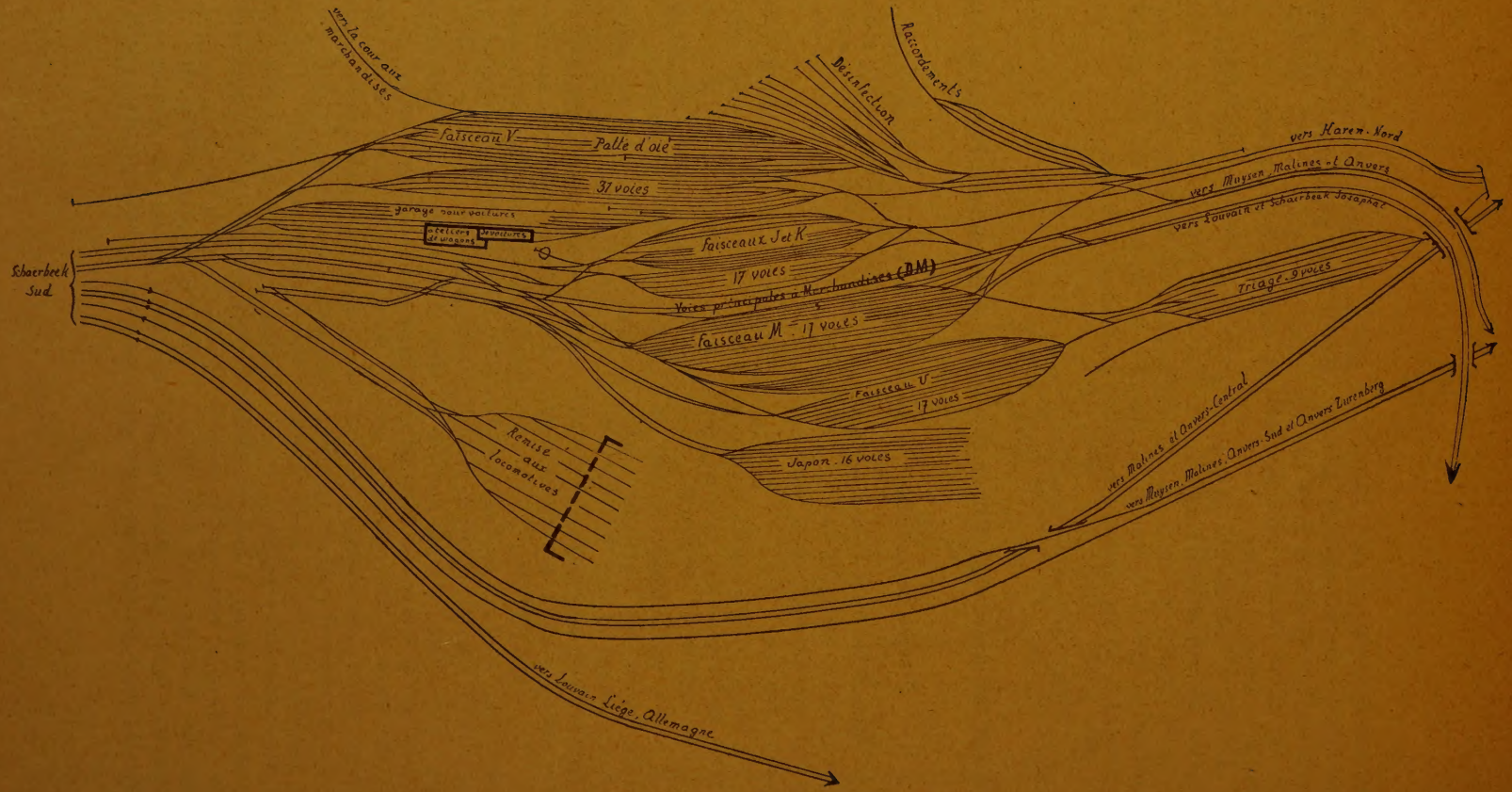
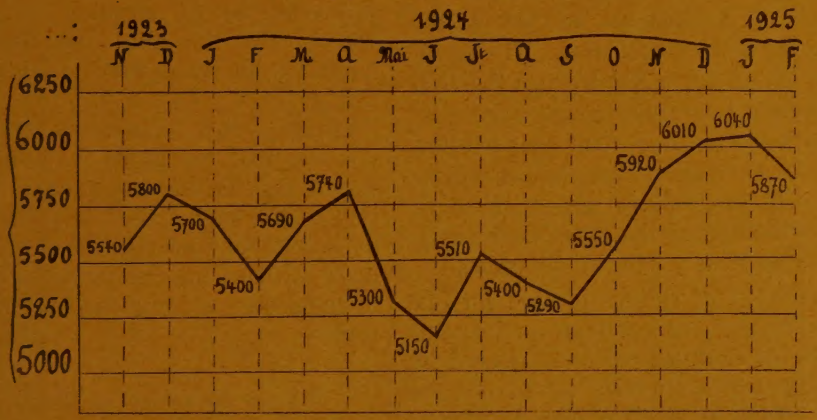


Fig. 2. — Existing lay-out at Schaerbeek-Formation.

two of these roads are utilised as draw-out roads for shunting on the humps of the latter groups of sidings; while the other roads are used for accommodating empty stock or trains which have been marshalled but which cannot be sent away immediately.

The average daily number of wagons entering and leaving the whole of the sidings is 5 600 (fig. 3).

Average daily wagon movements (inwards and outwards) at Schaerbeek-Formation Station.



Number of wagons in transit on hand in Schaerbeek-Formation Station at 7.0 a. m. each day.

Fig. 3.

This traffic has to be dealt with by 16 reception roads having an effective length of from 35 to 70 wagons, and by 66 sorting roads; the ratio between the capacity of the reception roads and the sorting roads, which is 25 %, is insufficient for the traffic which has to be handled, with the result that at busy pe-

riods trains have to be held back for lack of accommodation.

The number of destinations for which the traffic has to be marshalled in the station as a whole is 125, but by reason of the lack of accommodation, the number of sorting roads is much lower than the number of destinations for which the traffic has to be marshalled. The result is that except for a few traffics the first shunts cannot sort out enough wagons by destinations even important ones to allow them to be readily marshalled subsequently in geographical order; in short, the marshalling of the rakes in the sorting sidings is as a rule in any order.

If each set of sidings is used for one particular group of traffic, from the point of view of destinations to be served by the trains which are made up therein, the trains which it receives include wagons for various destinations, of which many have to be sent to other sets of sidings to be reforwarded. From statistics which have been kept, it is proved that before the institution of the new system of regulation, each set of sidings only dispatched directly 60 % of the wagons received, the remaining wagons being transferred to other sets of sidings whereas since this method has been brought into force, the average percentage is 82, which, having regard to the composition of the trains, is as good as can be expected.

It has therefore been necessary to provide roads for the interchange of wagons between the various sets of sidings. These interchanges give rise to difficulties in working : interruption in shunting, delay to trains entering and leaving, increased number of wagons passing over the gravity humps and damage to wagons which inevitably results from this process, all of which seriously reduce the output of the goods yard.

It will be seen from the above that it is advisable at Schaerbeek-Formation to know beforehand the composition of the 135 regular freight trains which stop there or are shunted so that one may choose the set of reception roads which will involve the minimum number of wagons to be transferred to other sets of sidings.

Finally, other difficulties arise from the fact that the goods yard includes a wagon disinfecting depot, and the location of the engine shed is such that the movement of the engines cannot take place without interfering with the work of the goods yard and the running of the trains.

§ 2. — Situation in the future.

For some years past, the Administration of the Belgian State Railways has recognised the necessity of completely re-organising the lay-out of Schaerbeek-Formation.

Thus, after the war, as soon as the financial situation permitted, a commencement was made towards replacing the goods yard, which we have just described, by another (figs. 4 and 5) having an area of about 500 hectares (1230 acres) including the plot of ground reserved for the engine sheds and their accessories.

The arrangement finally adopted will include a set of reception sidings (43 roads), a set of sorting sidings (52 roads) and a set of marshalling sidings (32 roads) arranged as conveniently as the available space will allow and forming a compromise between the requirements of the traffic, motive power and way and works departments. In fixing the ratio between the capacity of the re-

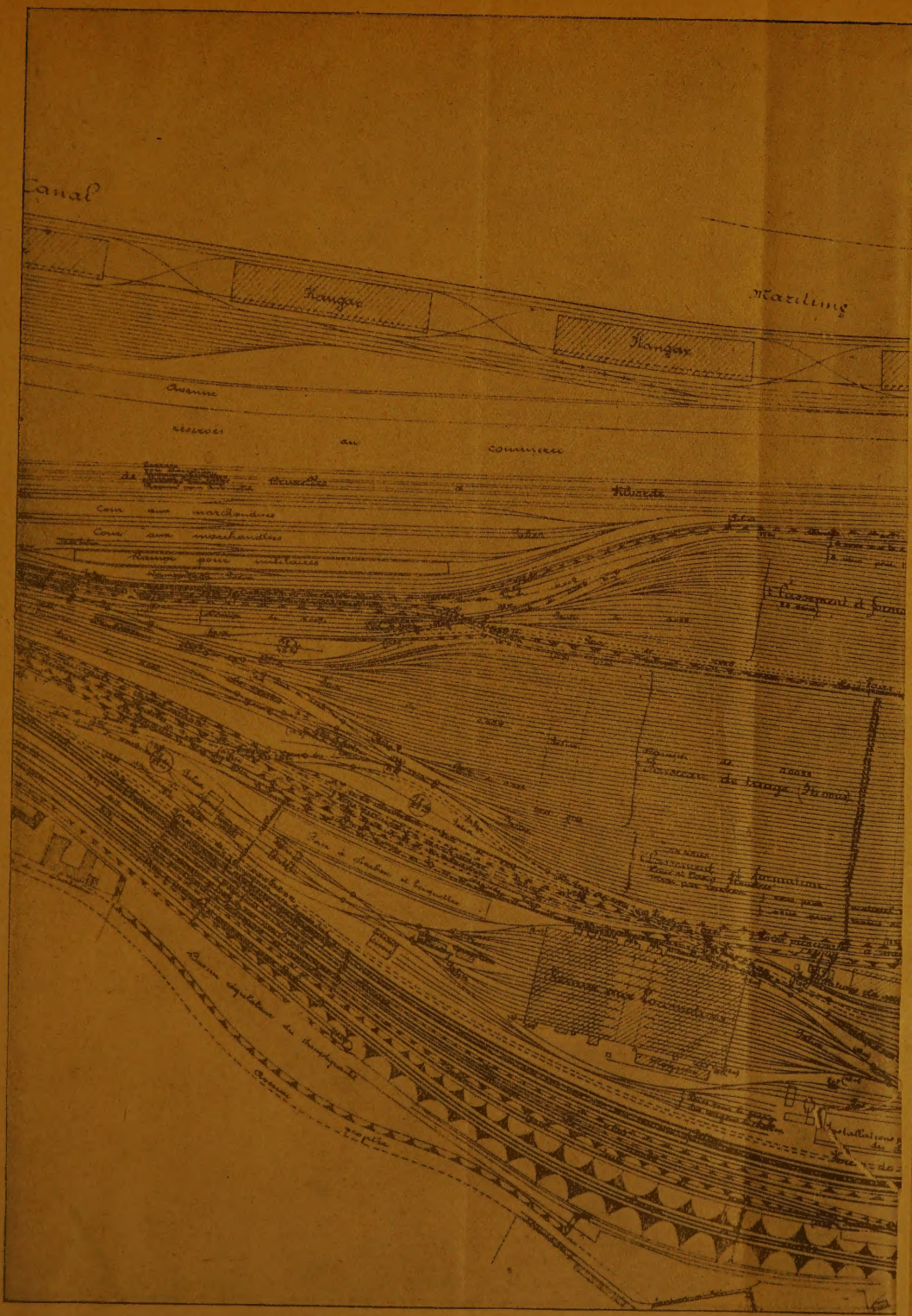
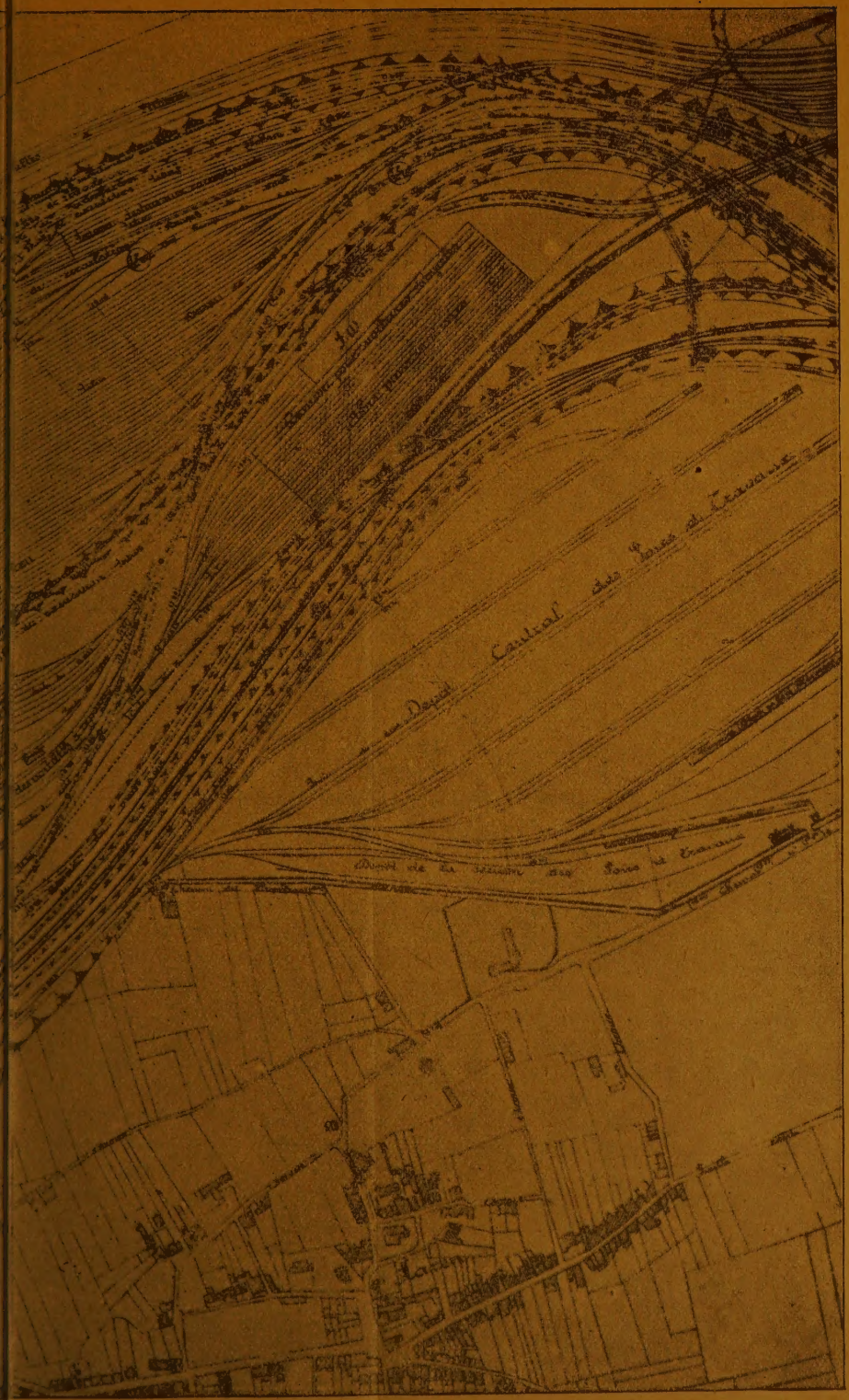

Canal
Hangar
Hangar
Marking
Cours
au
commerce
Cour aux marchandises
Cour aux marchandises
Rampe pour voitures
Bassin
Bassin

Fig. 4. — Future lay-out at Schaerbeek-Formation Station.



ception sidings and the sorting and marshalling sidings at approximately 50 %, one has been guided by the class and importance of the traffic to be handled, and by the necessity of providing sufficient roads so that trains can be received without delays, even when their running is irregular.

The scheme takes into consideration currents of traffic which it appears should develop or come into being and the conditions of future traffic at Brussels-Maritime and the industrial region of Haren and Vilvorde. As some of these requirements will not arise until a somewhat distant date, the marshalling sidings will not be constructed until later.

Passenger trains will run on their own particular roads, which are provided for trains in other direction. Freight trains which have not to call at Schaerbeek-Formation will also run over specially provided lines; those which have to enter the reception sidings will use incoming roads set aside for freight trains for a great length, and there will be avoiding roads which will allow light engines and through trains to pass without affecting shunting operations.

The sorting sidings will be placed as a prolongement of the reception sidings and will be separated from the latter by two humps over which the wagons to be sorted will be propelled by shunting engines. The wagons will be sorted by gravity on to the various sidings, and it will be possible, in view of the large number of sidings, to make up in one operation complete trains of empty stock or of wagons for the more important destinations. Il will be found also that after this has been done it will only require three or four movements to draw out the blocks of wagons at the South end and form them into complete trains. After this has been done, only those wagons which have to be included in the trains serving the intermediate stations are passed on to the marshalling sidings where they will be shunted by gravity. Until these lateral marshalling sidings are constructed, the marshalling in order of stations will be carried out at the South end of the sorting sidings by the use of four roads over a hump. At this end of the sidings, the roads for out-going trains will be sufficiently long to allow them to quickly clear the sorting sidings, even if the main lines are not clear.

It will be seen from this description that the lay-out has been devised in such a way as to obtain, as far as possible, movement in one direction only of the wagons being shunted and to allow the work of sorting to be carried out without interruption.

As regards the wagon repair shops, these will not be situated as at present in the centre of the reception and sorting sidings where they are an hindrance to the work of the traffic department, but will be located outside these sidings with which, however they will be provided with free access.

Although the extent and form of the available ground does not allow the engine shed to be placed in the most desirable position, it has been necessary to provide roads which allow independent access to engines proceeding from or returning to the shed; these roads will reach the centre of the yard under a bridge so as not to hinder the work of shunting.

This description of the existing and future lay-out at Schaerbeek-Formation station will make it clear, that if the operating system is based, in its administrative and telephonic organisation, on principles which may have a general ap-

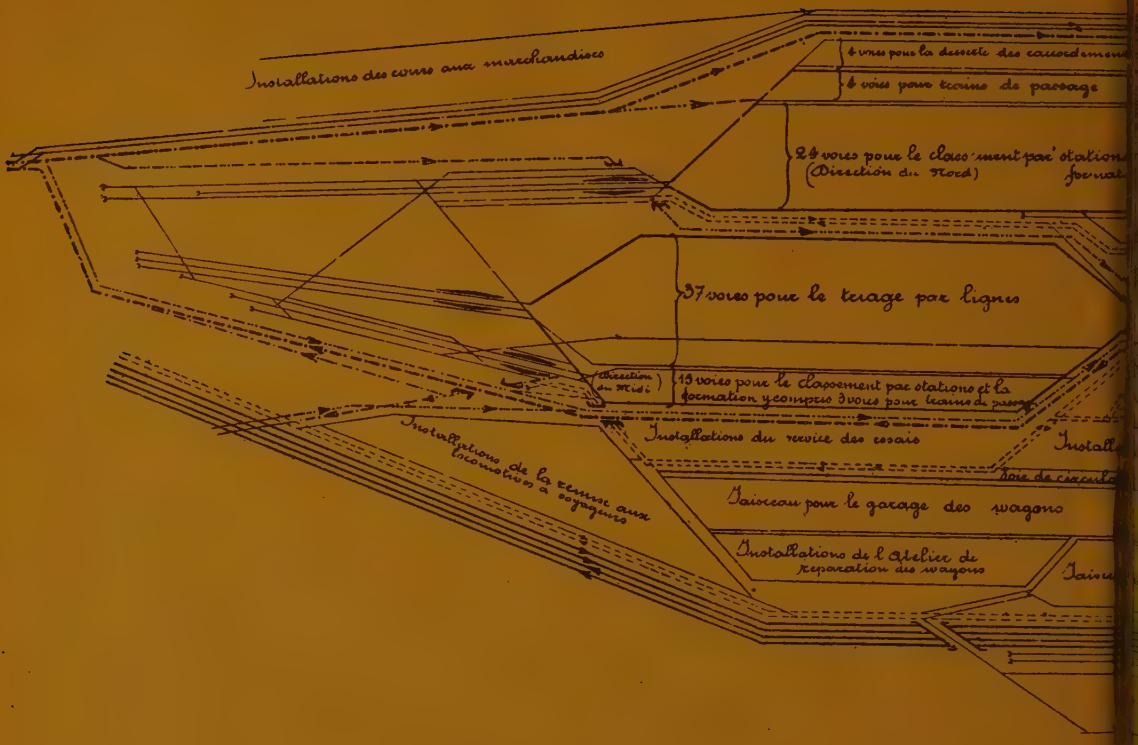
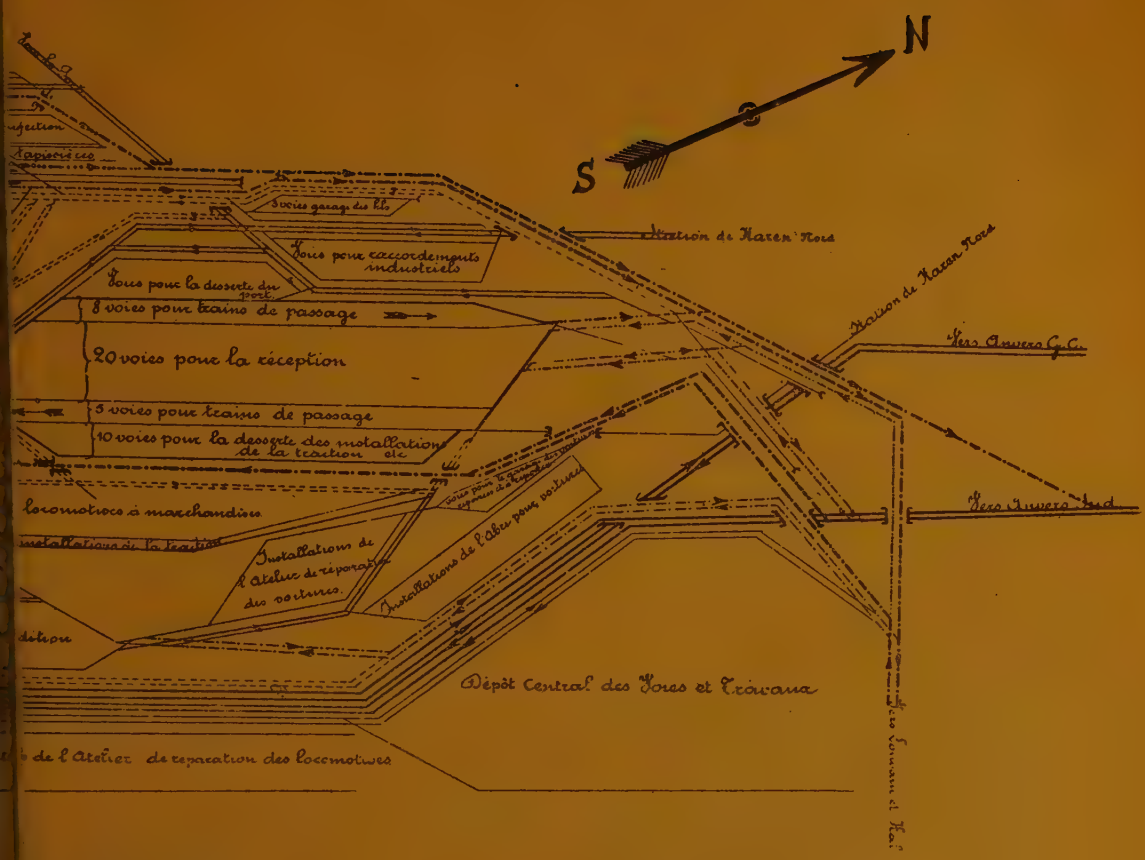

Installations des cours aux marchandises
6 voies pour la desserte des cabordements
6 voies pour trains de parcage
24 voies pour le classement par stations
(Direction du Nord)
37 voies pour le triage par lignes
(direction du Nord)
13 voies pour le classement par stations et la formation y compris 3 voies pour trains de parc
Installations du service des essais
Installations de la remise aux locomotives à voyageurs
Voie de circula
Faisceau pour le garage des wagons
Installations de l'Atelier de reparation des wagons

Fig 5. — Diagram of fut

Principal passenger lines.
Principal freight lines (direct).
Principal freight lines (for through tr
Principal freight lines (for arrriving


N
S
Station de Haren Nord
Vers Anvers Gare
Vers Anvers Sud
Dépôt Central des Voies et Travaux
20 voies pour la réception
3 voies pour trains de passage
10 voies pour la desserte des installations de la traction etc
Installations de l'Atelier de réparation des voitures
Installations de l'Abri pour voitures

haerbeek-Formation Station

——— Lines for use of light engines.

——— Additional lines.

——— Shunting dead-ends.

= Hump. — *N. B.* The outside limit of the groups of sidings are shown by a thick line.

plication, it will be, however, necessary to take into consideration the special circumstances of the actual traffic in this station to determine the duties of the Controller, especially as these should, as the works of the new goods yard advance, adapt themselves to the changes which may take place in the method of operation.

CHAPTER II.

Organisation of the control system.

It must not be thought from the fact that the creation of the control system at Schaerbeek-Formation is of recent date that this question has been neglected in the past.

At this station, in particular, one of the assistant station-masters has always, in fact, fulfilled the role of Controller, in that he has had to control the working of the station as a whole in the interest of the efficient running of the service, but he has been a Controller not provided with complete information.

It has not been possible for him, for lack of rapid means of obtaining complete information, to follow in detail the work of the sidings and to know exactly the situation along the line on either side of the station.

In this way the sidings easily became congested, their operations not being able to be regulated by a Controller in view of his inability to keep in close touch with the work, and instead of obtaining unity of control for the interior movements in the station, it has been necessary to decentralise the control between a number of assistant yard masters. This has of course led in certain circumstances to wrong movements being made, because these have not been carried out in complete unity of purpose.

The adoption of the « control or dispatching system » on the main lines leading to Schaerbeek-Formation and the placing at the disposal of the Controller of an improved telephone of the selector type (Western Electric Company's System) have allowed the duties and powers of this official to be extended, so that at the present time he is in possession, by means of the advance information supplied under the « control system » and the « operating system », of the necessary information to *foresee* difficulties and congestions, whereas formerly he had to wait until these occurred and then take what steps he could to *straighten out* the situation.

It has been necessary, it will be understood, to commence as follows :

— to free the controller of all duties other than regulation, so that being employed on one special duty he may carry this out to the maximum efficiency;

— to give him sole charge, and for this reason to choose him, not only from officials whose rank will give weight to their instructions, but those who inspire confidence by their force of character and knowledge of their duties;

— to provide facilities and necessary apparatus in order that he may be provided with all the necessary information.

Finally, it has been necessary to draw up rules governing the duties of the Controller and his assistants. These rules are contained in the following regulations :

§ 1. — Rules to be observed by the Controller and his assistants.

Article 1. — The system of operation consists mainly in concentrating in the Controller's office all information dealing with the running and organisation of freight trains and with the occupation of reception and interchange roads at Schaerbeek-Formation.

The Controller may thus issue from his office the necessary instructions with a view to maintaining or re-establishing regularity of working in the marshalling, reception and dispatching of freight trains.

Article 2. — The Controller's duties are carried out in the offices at Schaerbeek-Formation, and are covered throughout the whole 24 hours by an assistant station-master, assisted by a telephone operator.

These are directly responsible to the station-master.

Article 3. — The office of the Controller is connected by a special telephone circuit with selectors to the following posts (fig. 6) :

Signal box at Pont de la Senne junction;
Signal box at Josaphat junction;
Electric signal box at Maelbeek junction;
Assistant station-masters' office, Schaerbeek-South;
Signal-Box B (Monplaisir junction);
Signal box H (Malines and Muysen junction);
Signal box C;
Pointsman's box No. 11;
Assistant station-masters, V sidings;
Pointsman's box No. 11*bis*;
Pointsman's box D (engine shed yard);
Shed foreman's office;
Signal box G;
Pointsman's box at « Japan » sidings;
Foreman of brakesmen;
Pointsman's box No. 15 (South side of groups J and K);
Assistant-station-masters' office (South side of groups J and K);
Signal box J;
Pointsman's box No. 36 (South side of group M);
Pointsman's box, South side, group U;
Pointsman's box, North side, group U;
Pointsman's box No. 24 (North side of group M);
Assistant station-masters' office (North side of group M);
Signal box I;
Pointsman's box No. 19 (North side of hump);
Pointsman's box No. 21 (North side of hump);
Assistant station-masters' office (North side of group K);
Pointsman's box No. 16 (North side of group K);
Pointsman's box No. 17 (North side of group J);
Signal box E;
Signal box K;
Pointsman's box No. 1 at Haren-North;
Signal box at junction block 3*bis* M;
Signal box X (Schaerbeek-Josaphat junction);
Signal box Y (Dieghem junction).

The Controller's office is, moreover, included in the control circuits for the following lines :

Antwerp (South) and Antwerp (Zurenberg) to Schaerbeek and the Antwerp district;
Termonde to Louvain;
Brussels to Ciney;
Brussels to Liége;
Brussels to Ostend;
Brussels West Suburban;
Charleroi to Brussels via Baulers;
Mons to Brussels.

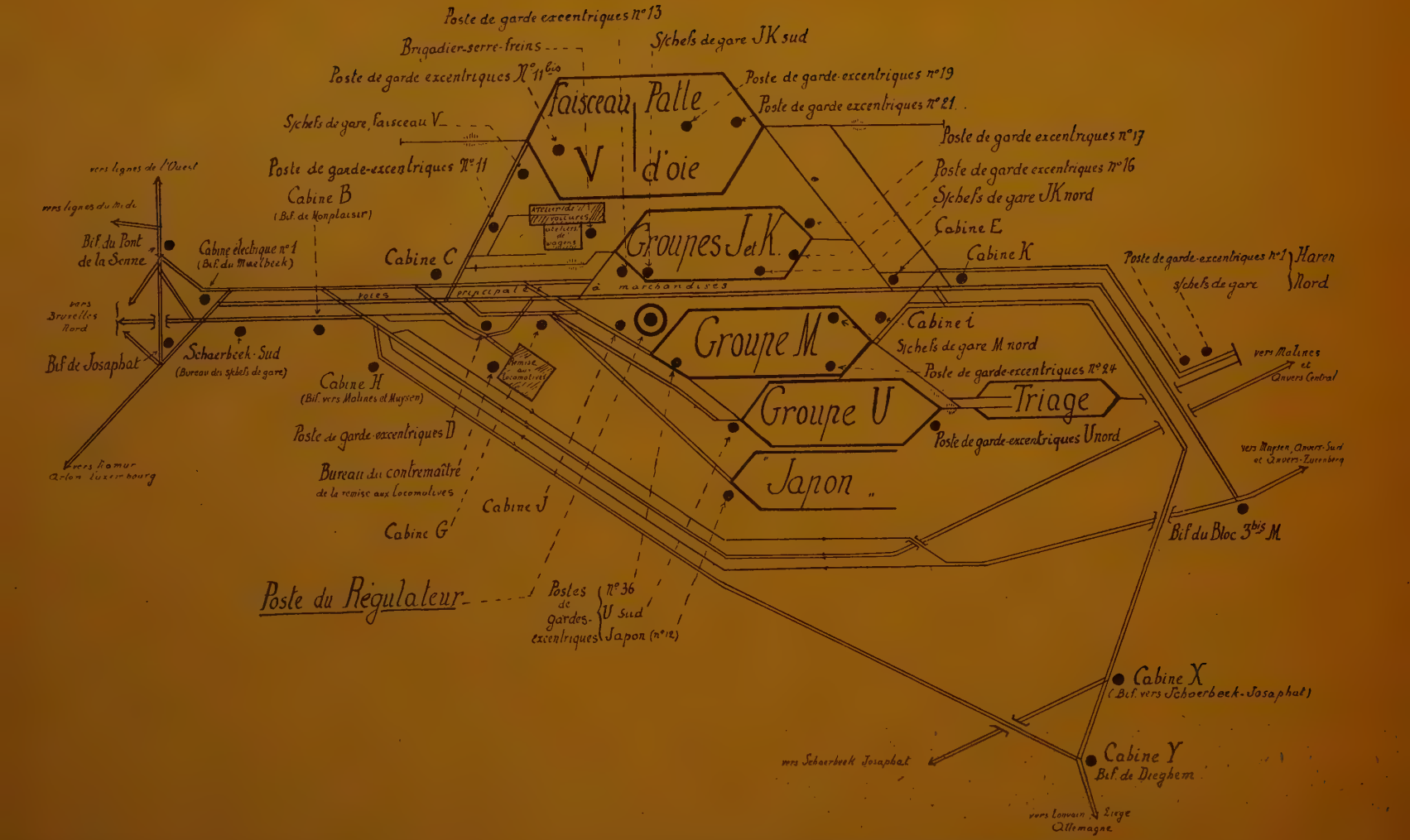


Fig. 6. — Diagram showing the location of the telephone sub-offices on the Controller's telephone circuit at Schaerbeek-Formation.

ARTICLE 4. — The Controller does not leave the telephone. He is solely responsible for controlling the order in which messages are sent.

Messages should be as brief as possible. In cases of great urgency, a sub-office may interrupt a message by calling its name and saying « urgent ».

It is strictly forbidden for any sub-office using the Controller's telephone circuit to speak to another sub-office. Every official or employee, whatever his rank, must conform to this rule.

ARTICLE 5. — The Controller co-ordinates :

1. information dealing with the organisation or running of freight trains or locomotives in the area bounded by the junctions at block post 3*bis* M and signalbox Y on the one hand, and the Josaphat and Pont de la Senne junctions on the other hand;

2. information dealing with the composition of freight trains booked to stop at Schaerbeek-Formation;

3. information received from the « controllers » as regards motive power and train crews for freight trains;

4. information dealing with :

a) the occupation or liberation of reception and interchange sidings;

b) a record (1) (fig. 7), of the wagons in the station, these being classified under 61 categories in accordance with their destination or station of origin.

c) the distribution of spare head guards.

(1) This record is kept in the form of a graph : on a sheet of squared paper, the number of wagons are marked off horizontally and the destinations or directions are arranged vertically. This gives a horizontal line for each destination or direction, two lines being drawn, one of each (in blue) represents wagons entering, and the other (in red) represents wagons leaving; the distance in millimetres between the ends of these two lines indicates the number of wagons in the station for the direction or destination in question.

ARTICLE 6. — The Controller is informed of the composition (number of wagons) in freight trains in the following manner :

a) the head guard enters the necessary information on a special form which he hands in at the last station, where any alteration is made to the composition of his train;

b) the station which receives this form from the head guard transmits the contents to the Controller through the « control » or by telegraph, in accordance with whether the line is operated on the « control system » or not.

ARTICLE 7. — The assistant station-masters inform the Controller without delay of changes which are made in the normal order in which trains run, and advise him in advance of shunting operations or special circumstances which may be expected to cause a train to run late.

The assistant station-masters inform the Controller of their requirements as regards special or conditional trains. The latter decides as to the necessity of running these trains, and where necessary arranges for motive power and train crews for the necessary trains.

All the sub-offices in the stations which are connected with the Controller immediately inform him of any mishaps, broken couplings, defective points, and generally speaking, of incidents which may influence the regularity or safety of the running of trains. However, such advices are only forwarded for his information and do not relieve the assistant station-masters or signalmen from the responsibility of taking the safety measures laid down in the regulations.

The Controller transmits, without delay, this information to the « control operators » concerned.

ARTICLE 8. — As regards reporting hours of the departure, arrival or passing of freight trains or locomotives, only

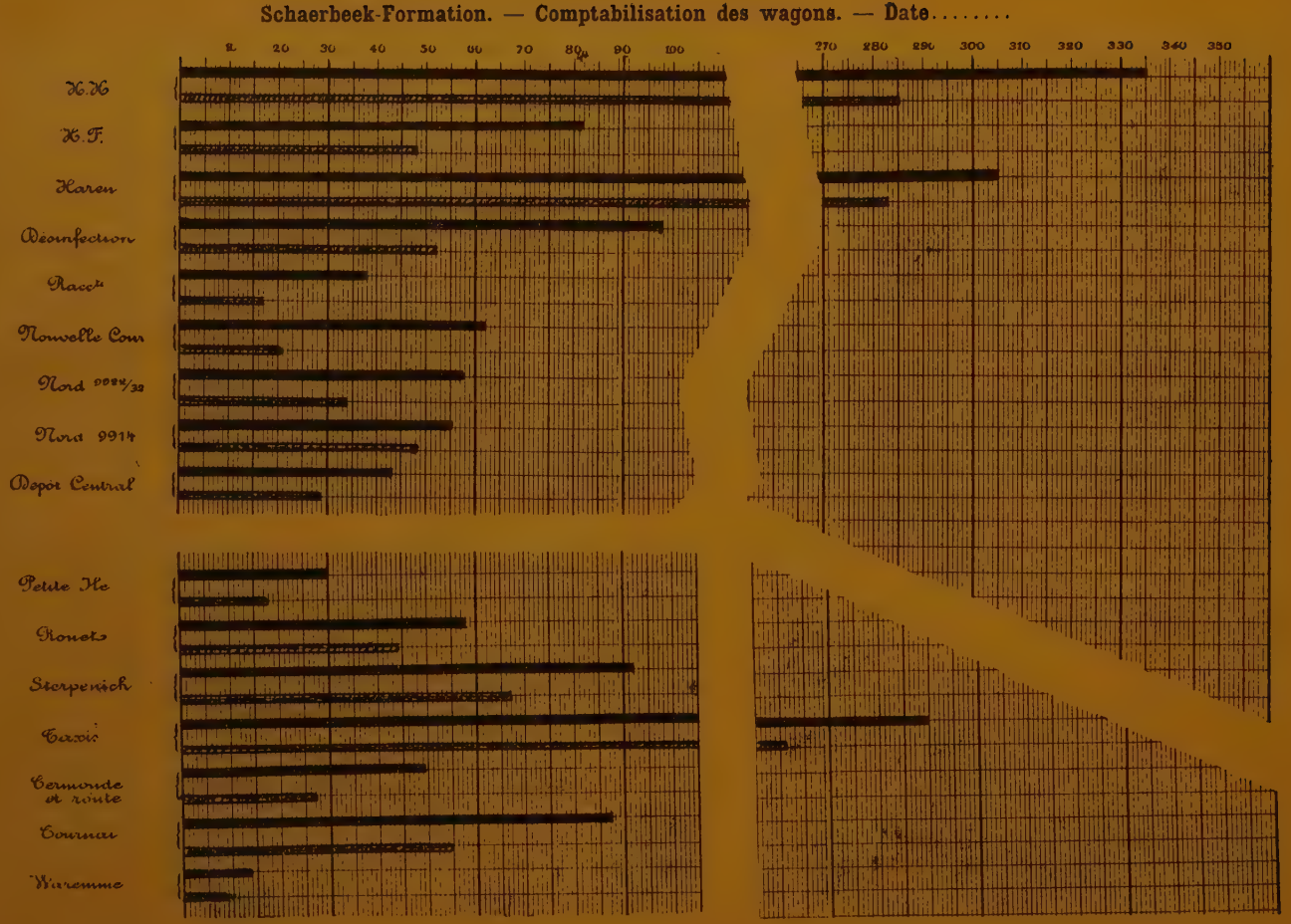


Fig. 7. — Chart showing number of wagons kept by the controller at Schaerbeek-Formation.

EXPLANATION : H. H. = Empty open wagon. — H. F. = Empty covered wagon.

Form used by head guards to inform the Controller of the make-up of a train entering Schaerbeek-Formation.

(FRONT)

TRAIN No..... for Schaerbeek-Formation.

Anvers (Zurenberg) (*).....	*Ligne Midi* (*).....
Anvers (Sud) (*).....	*Schaerbeek local* (*).....
Muysen (*).....	*Haren* (*).....
Ligne Est (*).....	*Bruxelles Tour-et-Taxis* (*).....
Ligne Denderleeuw (*).....	
Ligne Arlon (*).....	

(*) Number of wagons.

See reverse side.

(BACK)

The station which receives this form from the chief guard should dispatch the contents to Schaerbeek-Formation through the « control » or by telegraph in cases where the line is not worked under the « control system ».

the sub-offices given in the following list are concerned, and these are only	concerned within the limits laid down in this list.
Pont de la Senne signalbox	to and from Schaerbeek-Formation.
Signalbox A	to and from signalbox C, stating, for the direction in running between signalbox A and signalbox C, the route to be followed.
Signalbox B	from Malines, Muysen and Louvain to the main freight lines and *vice versa;* from the main freight lines and local lines to the engine shed.
Signalbox C	from the through freight lines to the engine shed and *vice versa;* announces also the arrival time and reception of wagons and locomotives from the shed to groups J, K, M, U and « Japan » and *vice versa.*
Pointsman's box No. 11.	to and from the carriage and wagon repair sidings.
*Pointsman's box No. 11*bis.	to and from group V; announcing the time of departure of rakes of wagons towards the hump and the time when shunting ceases.
Pointsman's box D.	gives the time at which all locomotives are ready to leave and states their destination.
Signalbox G	to and from the principal freight lines; also announces the arrival time and the receipt of wagons from groups J and K to groups M and U or « Japan » and *vice versa.*
Pointsman's box No. 13	to and from groups J and K; also announces the commencement and completion of shunting operations on the hump and especially intended to state when the reception roads of group K are liberated.
Signal box J.	to and from group M.
Pointsman's box of group U (South side)	to and from group U.
Pointsman's box of group U (North side)	announces the departure of wagons towards the hump and the time at which shunting ceases.
Pointsman's box No. 24	announces the departure of wagons towards the hump from groups M and the time at which shunting ceases.
Signal box I	to and from group M.
Points'man's box No. 16	to and from groups J and K.
Pointsman's box No. 17	announces the departure of wagons to the hump from groups J and K and the time at which shunting ceases.

Pointsman's box No. 19 . . . . . announces the time of the departure of wagons to the hump from the fan-shaped sidings and the time at which shunting ceases; it is especially intended to announce when the reception roads to the fan-shaped sidings are liberated.

Pointsman's box No. 21 . . . . . to and from the fan-shaped sidings.

Signalbox E. . . . . announces the time of arrival of wagons and locomotives from the fan-shaped sidings or from groups J and K on the main freight line or to group M and *vice versa*.

Pointsman's box No. 1 of Haren-North. . to and from Schaerbeek-Formation.

Junction 3bis *M* . . . . . to and from Schaerbeek-Formation.

Signalbox X. . . . . to and from Schaerbeek-Formation.

Signalbox K. . . . . announces trains kept standing at signals.

ARTICLE 9. — The Controller keeps in touch with the « dispatchers » to inform them of the number of trains which it is necessary to send out, and the number which he is able to receive within a certain time.

Every day, at 8.0 a. m., he sends out to the « dispatchers » concerned :

1. the regular trains, conditional trains or special trains which have to pass over the lines worked under the « control system » and which cannot be worked through lack of engine power or train crews;

2. special or conditional trains which it is intended to run over te said lnes.

Before sending to the engine shed a requisition for an engine to haul a special or conditional train, the Controller gets in touch with the « dispatcher » concerned in order to ascentain whether it is possible to make use of an engine which may be available on the line.

The Controller sends to the « dispatcher » concerned all information and particulars dealing with special or conditional trains, such information being laid down in the regulations dealing with the « control system ».

ARTICLE 10. — The Controller repeats to those concerned at Schaerbeek-Formation the information which he has received, and he decides upon the most suitable steps to be taken in the interests of the regularity of the service.

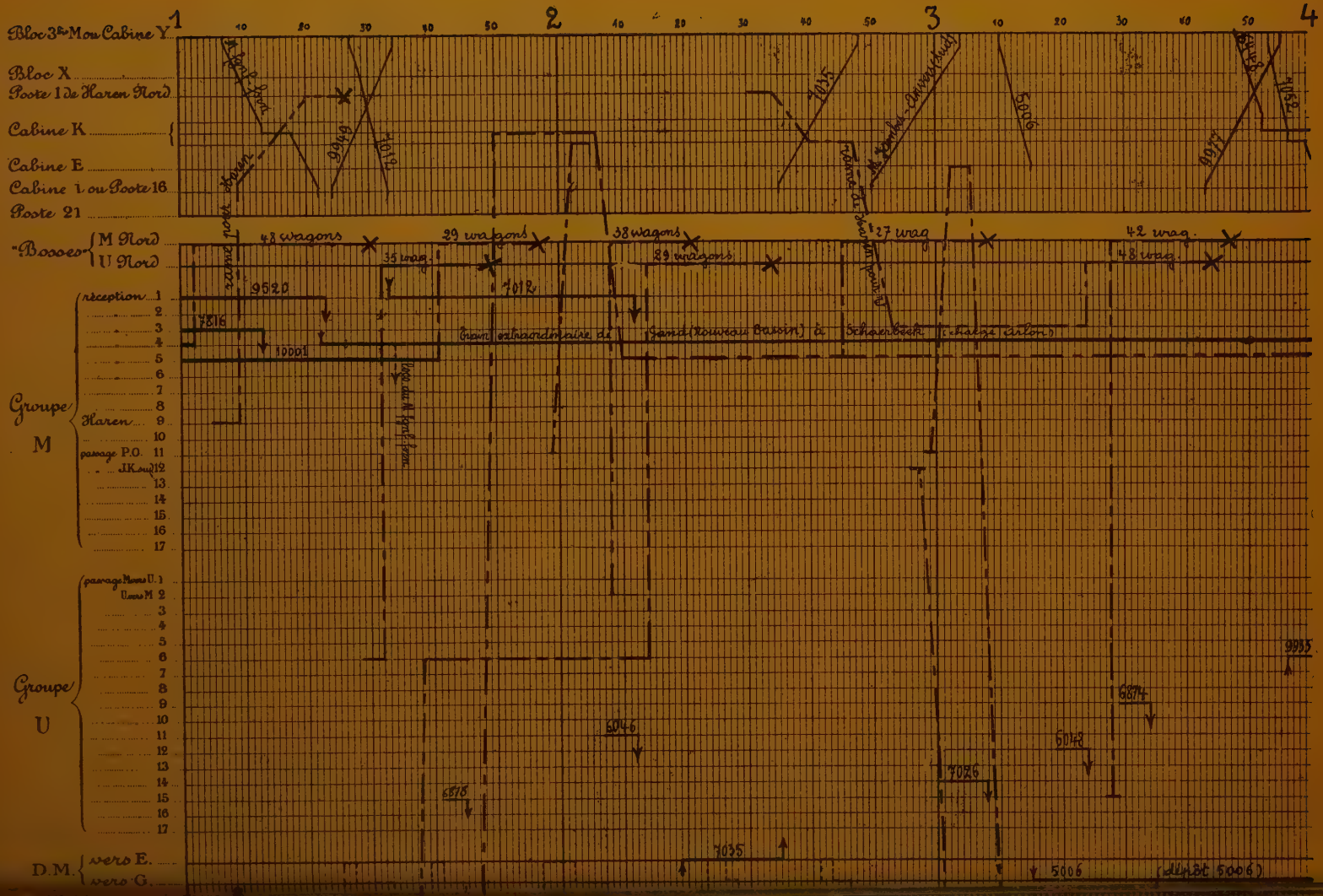
ARTICLE 11. — The Controller keeps a chart showing the movements taking place in the area under his control (art. 5-1).

For this purpose he enters upon a chart of squared paper (1) (fig. 8) :

1) the arrival and departure times of freight trains, of wagons and engines, and the times at which they pass certain posts in the yard (see art. 8) ;

(1) On the squared paper, time is plotted horizontally and the various signalboxes, reception, interchange and formation roads are shown one above the other; in this way one obtains a graph in which lines representing the running of trains and engines, or shunting operations, run up and down.

This chart is divided into three parts : the upper portion and the lower portion refer to trafns approaching or leaving Schaerbeek-Formation; the central part deals with the occupation of the reception roads, of the sorting sidings, and in general, all movements of trains, of wagons or engines which are not confined to the limits of one set of sidings.


Bloc 3ème Mou Cabine Y
Bloc X
Poste 1 de Haren Nord
Cabine K
Cabine E
Cabine L ou Poste 16
Poste 21
"Bossco" M Nord
U Nord
Groupe M
réception 1
Haren 9
passage P.O. 11
J.K. 12
Groupe U
passage Mons U. 1
U. sur M 2
D.M. vers E.
vers G.
1
2
3
4
10
20
30
40
50
43 wagons
35 wag.
29 wagons
38 wagons
27 wag
42 wag.
48 wag.
9520
7018
7016
10001
Grand extraordinaire 21
Gand (Nouveau Bassin) à
Schaerbeek
Voie de Haren à Bon Ferm
6046
6876
7035
5006
(depuis 5006)
9935
6874
6048
7026

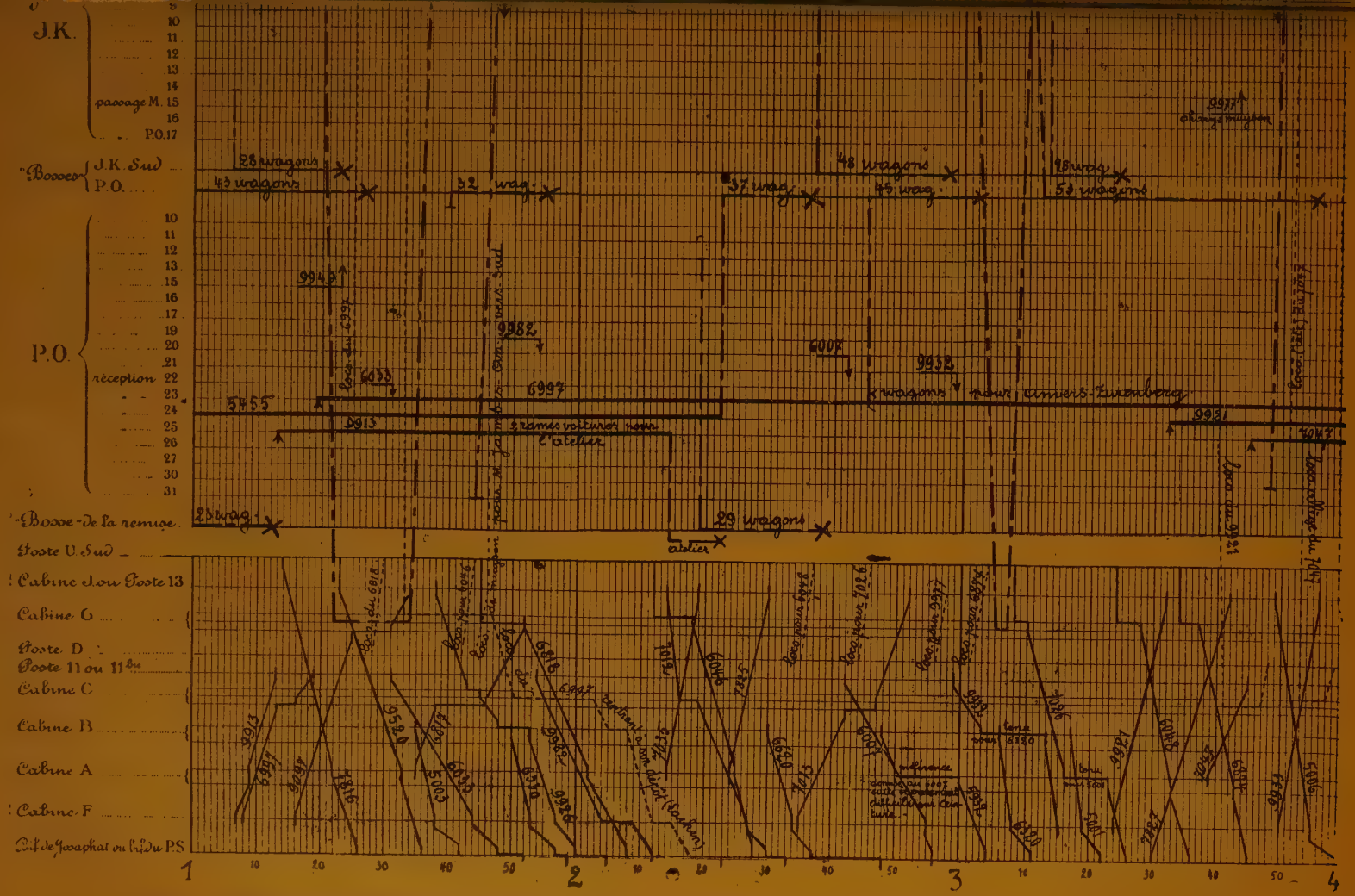


Fig. 8. — Chart of the movements of trains, of wagons or locomotives kept by the Controller at Schaerbeek-Formation.

Explanation of figure 8.

——————— = Freight trains.
——— — ——— — ——— = Shunting movements.
- - - - - - - - - - - - - - - - = Light engines.
M. = Special freight trains.
× = Termination of shunting operations.

TYPICAL EXAMPLES.

Train 6817, after passing signalbox A at 1.35 and standing eight minutes at signalbox C on account of the engine booked to work the special train from Jambes (Secours) to Antwerp (South), enters the first road of groups J-K at 1.52. The engine of train 6817 is liberated at 1.57 and is put at the disposal of the shed at 2.7; the engine at the tail of the train is sent straight back to the engine shed at 2.3. Train 6817, consisting of 48 wagons, is passed over the hump at J-K South and sorting operations finished at 2 58.

* * *

The wagons on road 7 of group J-K are transferred to group U commencing at 1.20. These wagons, after remaining on the main goods road from 1.22 to 1.34 to allow engines booked to work train 6818 and 9097 to be worked through, were accommodated on road 6 of group U, they being passed over the hump at group U-North at 2.14 and the sorting of the 29 wagons has been completed at 2.34.

* * *

Train 6033, marshalled on the 22nd road of the dead-end sidings, left at 1.31. This train passed signalbox F at 1.44 and left the precincts of the station at 1.52 after waiting for four minutes at Pont de la Senne Junction.

2) the reception roads which are occupied;

3) the times at which wagons which are to be sorted leave for the humps, and also the time at which this gravity shunting commences and finishes;

4) the movements effected to interchange wagons between groups of sidings.

On the edge of this chart is marked the occupation of the sidings « Triage » and « Japan ».

The Controller can therefore see at a glance what movements are being carried out in the goods yard.

In this way the Controller is able :

1) to determine with certainty at any given time which reception roads are clear;

2) to be in a position to state the probable length of occupation of these roads in accordance with the progress of shunting operations;

3) to so organise the work in conjunction with the « dispatchers » in order to hold back trains which are likely to interfere with the running of passenger trains or certain important freight trains;

4) to receive one freight train in preference to another because circumstances make it necessary;

5) to keep in touch with the running of freight trains and locomotives leaving Schaerbeek-Formation and to delay the departure towards a portion of the line which for the time being is congested so as to avoid delaying trains proceeding in other directions.

This chart allows the station master easily to determine :

1) delays in running, and especially loss of time by freight trains or engines at the various signals in the station;

2) delay in making use of motive power;

3) abnormal detention in the station of engines which have worked trains arriving at Schaerbeek-Formation;

4) the output of the gravity humps.

The Controller attaches to the chart a statement of any irregularities which may have occurred.

The station-master compares the chart with his reports of late running and investigates and reprimands anyone causing irregularities; if necessary he proposes modifications to be made in the time-tables in order to facilitate the interior working of the station.

When, in accordance with the first paragraph of article 9, it is necessary, when traffic is very heavy, that the Controller shall have sufficient warning of the approach of freight trains to Schaerbeek-Formation, he represents on a wall diagram, by means of metal tablets, the position of trains along the line (fig. 9).

These metal tablets may be caused to slide along rigid wires representing about the last 30 km. (19 miles) of each line approaching Schaerbeek-Formation.

The tablets are marked with the number of the train, and if necessary, its place or origin, destination and load. They are moved along the wire as the progress of the train is reported to the « dispatcher ».

On the arrival of the train, the tablet is placed on the wire representing the reception road; after it has left or has been distributed, the tablet is re-marked.

Article 12. — The Controller is solely responsible for providing engine power and train crews for conditional or special trains, and decides which shall take precedence.

The Controller may alter engine workings and the duties of the brakesmen, with the consent of the motive power department.

The engine shed at Schaerbeek should obtain from the Controller any information which it requires, and should at once inform him of any lack of engine power to meet the needs of the station.

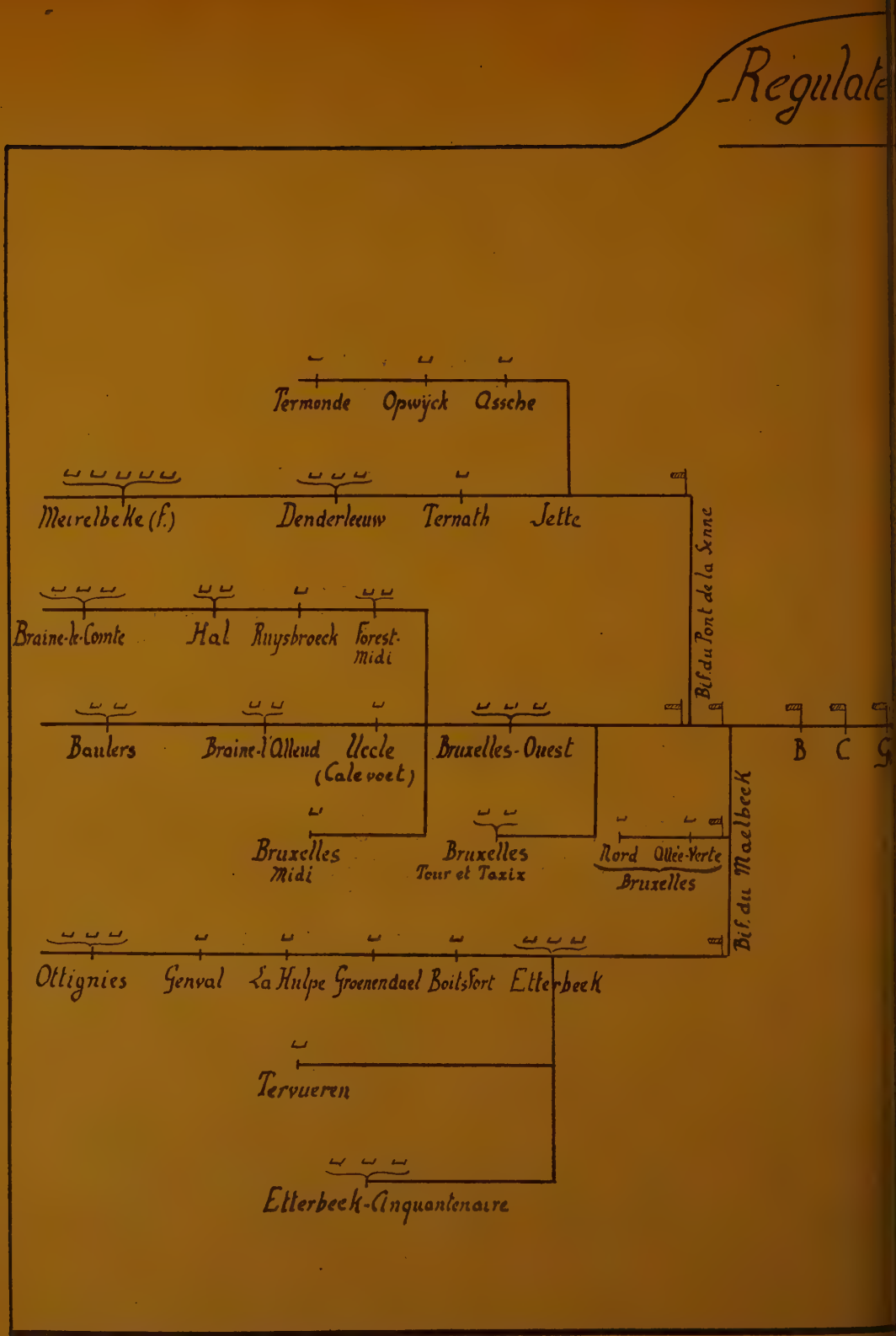
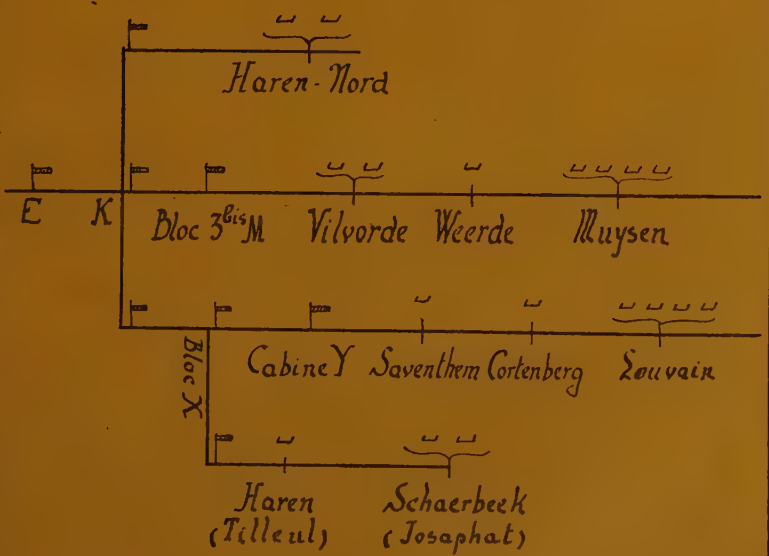


Fig. 9. — Wall chart used for showing, by means of movable ta

erbeek

DM ←

M	U	Triage	
1	1	1	
	2	2	
2	3	3	
3	4	4	
4	5	6	
5	6	8	
6	7	9	
7	8	Japon	
8	9	1	11
9	10	2	12
10	11	3	13
11	12	4	14
12	13	5	15
13	14	6	16
14	15	7	
15	16	8	
16	17	9	
17		10	



h of trains and the length of time they remain in the station.

Article 13. — The station-master shall issue to each telephone post special instructions, in which are laid down the form in which messages are to be transmitted. He makes the necessary arrangements so that calls from the Controller shall be replied to without delay, so that the latter may be quickly supplied with information which has to be forwarded to him as a matter of course, or any additional information for which he may ask.

Article 14. — Except as regards the application of the arrangements quoted in articles 6 and 11, this new organisation shall not supersede or modify in any respect the mutual arrangements made between Schaerbeek station and the district « control » office, which arrangements are laid down in the notices issued when the « control system » was brought into force on the various sections.

The same applies to any local orders or instructions of a domestic nature in force at Schaerbeek-Formation.

Article 15. — The Controller is authorised to issue instructions to assistant station-masters, and in taking steps in conformity with orders received from the Controller, the assistant station-masters are still fully responsible for the observation of the rules and regulations for ensuring safe working.

The Controller is responsible for the orders which he issues, but this responsibility naturally falls on the assistant station-master if the latter does not strictly comply with these orders, or if he leaves the Controller in ignorance of facts or circumstances which might modify or cancel these orders.

The Controller is responsible for all the irregularities due to lack of instructions or oversight on his part. However, this does not relieve the assistant station-masters from the responsibility of obtaining from the Controller any information which they may need in order to deal effectively with the operations in hand. They will be especially held responsible if, through lack of information which might have been obtained from the Controller, they make mistakes which disorganise traffic movements.

In case of difficulties, the Controller should refer the matter to the station-master.

The system of regulation furnishes the station-master with rapid means of ascertaining at any time the progress of operations in the station, and allow him to make suitable arrangements to meet the existing circumstances.

§ 2. — Telephone and other electrical apparatus provided for the use of the Controller.

As the Controller can only carry out his duties, provided he is rapidly informed of all movements in hand, it has been recognised as desirable to put at his disposal selector telephones of the Western Electric Company's type, as already used on the lines of the Belgian State Railways worked under the « control system ».

This apparatus has been described in detail in an article published by Mr. Lamalle, Director of the Belgian State Railways and Professor of Louvain University, in the *Bulletin of the Railway Congress*, November 1922 number. We will confine ourselves therefore to a few general remarks on this equipment.

The Controller's office (fig. 10) is situated in the centre of Schaerbeek-Formation close to the office occupied by the chief assistant to the station master and close to the accommodation provided for the head guards, goods agents and lamp men.

The office of the Controller is connected by a single two-wire telephone circuit to 36 sub-offices in the station yard, or at the neighbouring junctions. He is in

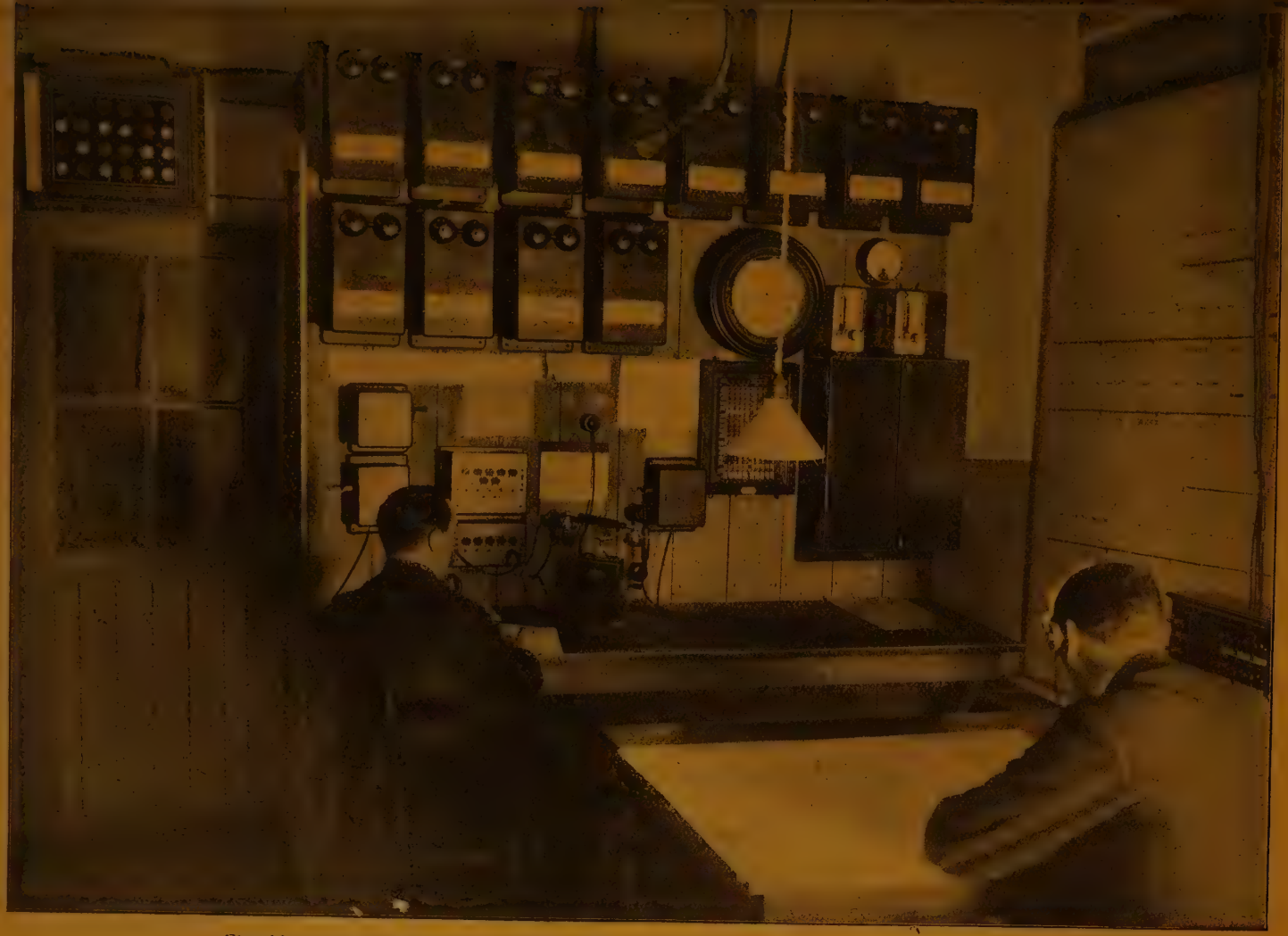


Fig. 10. — View of the interior of the Controller's Office at Schaerbeek-Formation.

this manner in direct communication with the assistant station masters in the sorting sidings, the signalmen at the junctions, the pointsmen, the chief of the locomotive shed and the foreman brakesman.

The controller, unlike the sub-stations, is able to call up at will any of the sub-stations. He is provided for this purpose with a board fitted with selector keys, each of which when moved operates all the selectors, but only puts into the calling-up position the selector corresponding to the particular key. When this is done, a bell rings in the sub-station called up and at this sub-station only. To effect this selection, the Controller has only to raise the key corresponding to the sub-station which he wishes to call up. When the key is released, it returns to its normal position, sending out, during its movement, a series of positive and negative impulses. The total number of these impulses is the same for any sub-station, but they are grouped differently in three successive series, separated by pauses (as $9 + 5 + 3$, $7 + 5 + 5$, $3 + 2 + 12$, etc.).

On the other hand, as all the sub-stations are on one circuit, the operator at the sub-station can hear what is being said over the telephone, and if no conversation is in course, or as soon as this is ended, may enter into conversation with the Controller without having to call him up, as the latter is always listening in.

This telephone system gives rapid and satisfactory working. It increases the number of messages which the Controller may receive, seeing that they are received over the same circuit and in order of priority, while reception of messages by a separate circuit for each sub-station or a series of sub-stations would not allow this freedom of selection or the same rapidity in the interchange of messages.

In addition to this selector circuit, the Controller is provided with direct telephonic communication with the central exchange at Schaerbeek-Formation, which thereby allows him to communicate with certain secondary offices which it is not necessary to include in the main circuit.

In case of breakdown of the special regulation circuit, this arrangement allows him to still keep in touch with the sub-stations by means of the ordinary telephone system.

Finally, to allow the Controller to know the position as regards all incoming traffic, he may, by operating a switch, cut into any of the « control » circuits for the lines approaching Brussels.

As the station master is frequently detained by his duties at the offices at Schaerbeek-South, which is about 1.2 miles from the Controller's office, another need which has to be met consists of providing this office with an indicator giving at any time the condition of the arrival roads at Schaerbeek-Formation. This information is for the station master at such an important place as Schaerbeek the most valuable of all the duties carried out by the Controller; it allows him to grasp the situation at the station, to question the Controller without loss of time, and to assist him with his experience or with his authority.

This problem is met by means of two indicators provided with discs, one of which is placed in the station master's office and the other to control the workings in the Controller's office.

These indicators (fig. 11) have a number of holes in their face, each of which represent one of the reception roads.

Normally, these holes display a white disc which, when moved away, shows a red background.

The indicator which is placed in the

Controller's office is provided with a row of push buttoms, there being two push buttons for each hole.

Fig. 11. — Disc indicator apparatus placed in the station master's office to show the state of occupation of the reception roads at Schaerbeek-Formation.

By pressing one of these buttons, the white disc is displaced and the red background is shown. By pressing the second button the disc returns to its normal position.

The method of working is as follows : The white disc indicating that the particular reception road is clear, while a red disc indicates that the road is occupied.

The electrical apparatus for operating this is very simple. Behind each hole, arranged perpendicularly at the back of the case, are two electro-magnets which are wound so that, the like poles are both side by side. Between these electro-magnets is a permanent horse-shoe magnet which may be displaced by rotation about its axis. This magnet carries the disc and is normally in contact with the poles of one of the electro-magnets. By pressing the button which displaces the red colour, the electro-magnet in contact with the permanent magnet is excited and has such a polarity that similar poles are close to each other. This produces a repulsion which causes the permanent magnet to deflect and be attracted by the pole of a second electro-magnet. By pressing the second button, the latter electro-magnet is excited, the permanent magnet is deflected back and the white disc again appears.

CHAPTER III.

Results and conclusions.

The innovation does not consists of entrusting the control of the whole of the interior movements in the station to one Controller. Such a Controller already existed, but he was not provided with reliable, complete and rapid methods of collecting information whereby he could always exercise efficient control. Moreover, the information which he had did not always show the various phases of activity so that he could quickly sum up the difficulties which had to be overcome by the staff and act with certainty that the instructions given should be the most suitable under the circumstances.

In bringing into force with the existing staff the regulating organisation, the Belgian State Railways have attempted to make good certain wants. In place of a centralised control working in the dark,

has been substituted a fully informed organisation operating authoritatively and using the methods of the « control system ».

At Schaerbeek-Formation station, at which a large number of lines worked under the « control system » meet, the duties of the station Controller and of the train dispatchers are complemental. These officials, who are responsible for sections which terminate at the station, must always keep in touch with one another, and by mutual arrangement they endeavour :

— to make use of locomotives on the return journey;

— to run the minimum number of freight trains by seeing that these are fully loaded;

— to make the best use of existing facilities (locomotives, head guards, brakesmen) in order to run the conditional or special trains which may be required or which are awaiting dispatch.

It will be appreciated that it is very difficult to discriminate between the effects of these two kindred organisations, so as to be able to state what reduction in expenses is due entirely to the influence of the Controller.

It is not very easy to express in figures the economies which the Controller is able to effect within his own zone of action without external co-operation. The working of a large marshalling station depends on a number of variables which can hardly be evaluated or which may appear as the result of a number of circumstances outside the control of the Regulator.

Notwithstanding this, however, the results which have been obtained are sufficiently significant without the necessity for expressing these in figures. The avantages are as follows :

— regularity in the running of trains;

— acceleration of the traffic by receiving a train in the sidings which are most suitable for re-dispatching in accordance with the destination of the wagons;

— obtaining better utilisation of the regular trains and a reduction of a number of conditional or special trains;

— control of the use of locomotives in the station and an increase in their output;

— liberation of the engines of arriving trains and working engines to and from the shed without hindering the work of the station;

— a better organisation of the interchange of wagons between various groups of sidings;

— the possibility of regulating the arrival of incoming trains in accordance with the accommodation available at the time.

As a concrete example, it may be stated that during the last period of heavy traffic, the station has had a daily output of 300 to 400 wagons greater than at the corresponding previous period without it being necessary to obtain any additional engine power or staff, and without any difficulty having been experienced.

Finally, in addition to these advantages there are others whose effect is less apparent, because they affect the efficiency of the personnel, and these are none the less valuable. We refer to the beneficial influence which a control of the movement of trains and of shunting operations by means of a graphical representation have upon the activity and energy of the staff. These diagrams clearly illustrate the importance and advantage of the assistance

given, as they show in an irrefutable manner the effect of irregularities, accidents or errors of judgment. The influence and authority of the chief officials have become very efficacious, while the subordinates, feeling that they are being constantly assisted and supervised, see that their efforts are better recognised and their responsibitily more clearly laid down, and the efficiency of the staff has certainly improved.

To sum up, the experience which has been gained over nine months with this method of controlling the interior movements in a large marshalling yard by means of telephone control, allow one to arrive at a definite conclusion of a general nature, that *the system is excellent.*

[62. (01 (.52) & 625 .143.5 (.52)]

On a new magnetic rail defecto-scope,

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ENGINEER, RESEARCH OFFICE, JAPANESE GOVERNMENT RAILWAYS, TOKYO (JAPAN).

Figs. 1 to 25, pp. 326 to 343.

I. — Introduction.

The determination of the strength or detection of in-homogeneity of rail steel and other metallic materials has undoubtedly become of late more and more important. Methods so far used for testing such kinds of materials are tensile, compression, bending, torsion, hardness testings, analysis of chemical composition, etc., but with these methods, specimens once submitted for testing, cannot be put again in service as industrial material. Moreover, the value of these tests is based upon the assumption that the structure and manufacturing process of such industrial material are quite the same as those of their specimens tested. In longer materials, it is difficult to ascertain whether their cross section at any point has always homogeneous structure and uniform strength throughout the whole length. As for instance, railway rails and bars cannot always be free from in-homogeneity. In some rails already laid on track, we find fissures, unseen from outside (called transverse fissure, see figure 14), spots affected by abnormal stresses, segregation of impurities due to careless or poor manufacture and unequal heat treatment. Detection of such faults or defects has been impossible by the testing methods formerly used. We will here make a report on study of a new apparatus which has been devised in our laboratory for detecting from outside any internal defects existing in railway rails and other iron or steel materials having uniform cross section, without inflicting damage on the materials tested.

As explained later, this apparatus is intended to ascertain internal defects by means of magnetic induction properly applied. We have named this apparatus as « Magnetic rail defecto-scope ».

As regards other magnetic rail defecto-scope, Dr. P. H. Dudley (1) has already published an interesting paper on an apparatus for detecting faults of steel rails. The first introductory note on the magnetic behaviour was prepared by Dr. C. W. Burrows (2) and F. P. Fahy, U. S. Bureau of Standards, the principle being that there exists a close relation between magnetic and mechanical properties of rail steels. Some monographs on general subject of magnetic analysis were also prepared by Prof. S. R. Williams, Oberlin College and N. J. Gebert, Metallurgical Dept., Holy & Co., New York.

They have pointed out that the magnetic analysis may be applied to the study of effects of heat and mechanical treatments

(1) P. H. Dudley, *Iron Age*, vol. 108 (1921), p. 1271, and vol. 104 (1919), p. 43. — P. H. Dudley, A. S. T. M., vol. 19 (1919), p. 51.

(2) C. W. Burrows and F. P. Fahy, A. S. T. M., vol. 19 (1919), p. 7.

of steel; that it may be resorted to for detecting flaws in ferrous metals having uniform section such as steel rails or bars.

For the purpose of finding defects, they used total magnetic flux method; and if took 25 minutes to complete a series of surveys on one rail, one half of the time being required for handling the rail on and off the vertical support. It may easily be conceived that Dr. Dudley's magnetic rail defecto-scope cannot be used in the field work on account of its non-portability; and curves recorded for defects are not sharp enough to make rail defects easily ascertained.

In the present study, a step has been made forward. Instead of Dr. Dudley's complicate and non-portable apparatus, a very simple and portable one has been devised, using leakage magnetic flux method. The tests with the latter took place during 1920-1922, the number of rails tested amounting to 100. One or two minutes were required to complete a series of tests on one rail. Detailed description will be made in later chapters. It may be added for readers' information that this method can be applied only to ferro-magnetic materials, such as of iron or steel, having uniform section.

II. — Apparatus and testing method.

In general, it is well known that when ferro-magnetic substance such as iron or steel is placed in an intense magnetic field, it is at once magnetized by magnetic induction and becomes a strong magnet. The intensity of magnetization varies much with the property of substances concerned and also with mechanical and heat treatment previously applied to them. For instance, the intensity of magnetization of carbon steel decreases as the content of carbon increases. Again, it is a well-known fact that the intensity of magnetization, that is, the magnetic permeability, varies in wide range with forging, heat treatment, etc.; in other words, the intensity of magnetization is much affected by stresses due to external force. Not only is the permeability of ferro-magnetic substance so seriously affected by heat treatment and mechanical stresses, but impurities and slag are known to have a great influence upon the permeability (μ).

Here we shall see the relation between magneto-motive force, magnetic flux and magnetic reluctance.

Let

N stand for the total number of turns of the magnetizing coil;

l stand for the axial length of magnetizing coil, in centimetres;

n stand for the number of turns of the magnetizing coil, per unit length of magnet, that is, $\frac{N}{l} = n$;

i stand for the current in the magnetizing coil, in amperes;

H stand for the magnetizing force in c. g. s. unit (gausses).

Then we have :

$$H = \frac{4\pi N i}{10 l} = 0.4\,\pi n i \text{ in gausses.}$$

This is the magnetizing force produced in a magnetizing coil when a current of i amperes flows through the coil.

Further, let

S represent the cross sectional area of iron core, in square centimetres;

μ represent the permeability of core iron;

B represent the magnetic induction in gausses;

Φ represent the magnetic flux due to magnetic induction.

Fig. 1. — General view of a new magnetic rail defecto-scope.

LEGEND : A = Driving truck. — B = Electro-magnet. — C = Recording apparatus. — D = Battery.

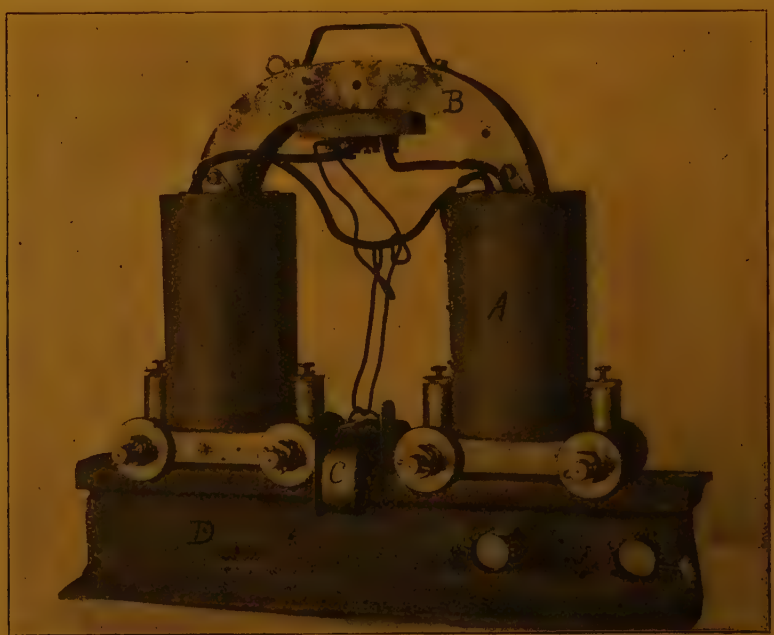


Fig. 2. — Detailed view of the electro-magnet laid on a rail.

LEGEND : A = Magnetizing coil. — B = Iron core. — C = Exploring coil. — D = Rail.

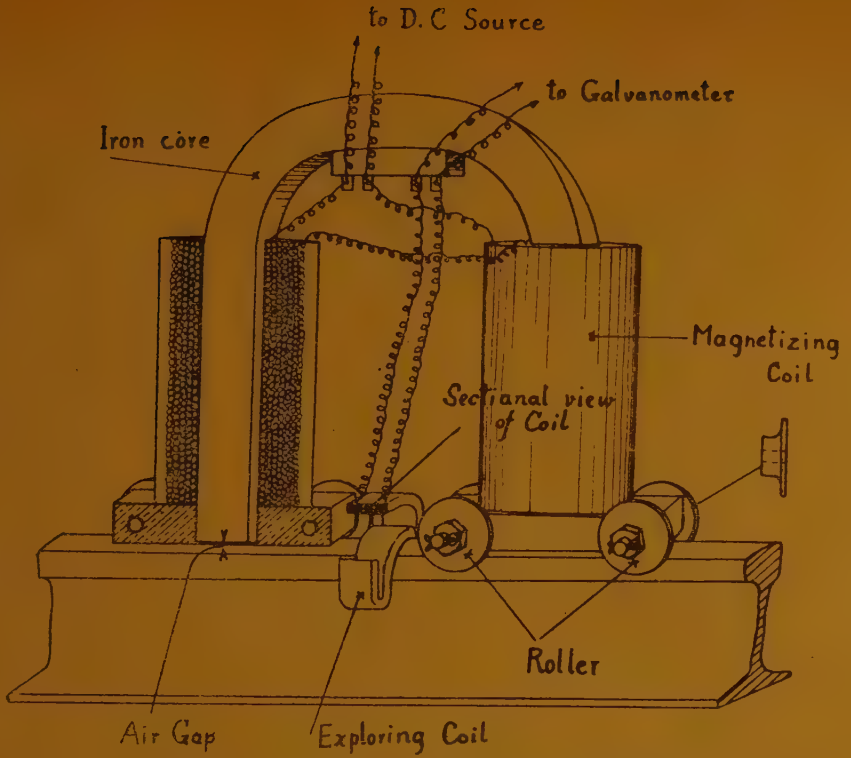


Fig. 3. — Sketch of the electro-magnet laid on a rail.

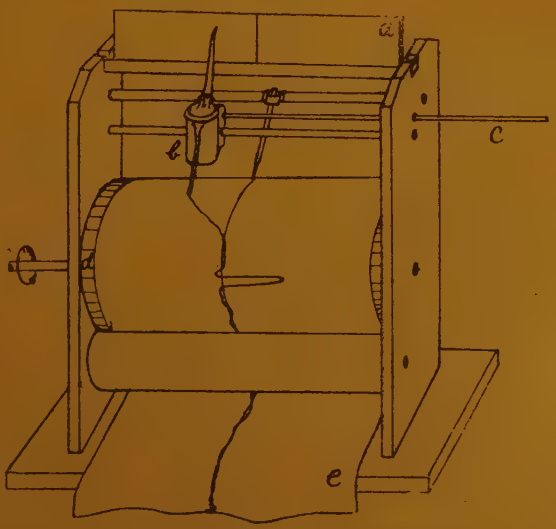


Fig. 4. — Detailed view of the recording device.

LEGEND : *a* = Frosted glass. — *b* = Pen holder. — *c* = Pen handle. *d* = Recording drum. — *e* = Recording paper. — *f* = Spindle extending from clockwork.

Then we get following relation :

$$\Phi = BS.$$

Since

$$B = \mu H,$$

$$\Phi = \mu HS = \frac{0.4\pi NiS\mu}{l} = \frac{0.4\pi Ni}{\frac{1}{\mu}\cdot\frac{l}{S}} \text{ in gauss.}$$

This denotes magnetic flux Φ produced by the magnetizing force H in iron core with permeability μ and cross sectional area S square centimetres.

Readers will see a close similarity between the above expression and Ohm's law concerning the electric current. Now let the passage of the magnetic flux be called « magnetic circuit », the magnetizing force $0.4\pi Ni$ affecting this circuit be called « magneto-motive force », and $\frac{1}{u}\cdot\frac{l}{S}$ be called « magnetic resistance » or « reluctance ». (The first is so called after the name of « electric circuit », the second after that of « electro-motive force » and the third after that of « electric resistance ».) Then it will be seen from the above expression that the magnetic flux is directly proportional to the magneto-motive force $0.4\pi Ni$ and inversely proportional to the reluctance $\frac{1}{u}\cdot\frac{l}{S}$.

Of the magneto-motive force and reluctance, N, i, l and S must be constant after the electro-magnet has once been settled; so, it is clear that the magnetic flux Φ is the function of the permeability μ alone. Therefore, if any other magnetic substances with different section and permeability happen to be in the magnetic circuit, then the magnetic flux Φ becomes as follows :

$$\Phi = \frac{0.4\pi Ni}{\frac{1}{u_1}\cdot\frac{l_1}{S_1} + \frac{1}{\mu_2}\cdot\frac{l_2}{S_2}}.$$

In this expression, the value of μ varies with the property of iron; with pure iron, $\mu = 2\,000$, with steel, $\mu = 400$, and in the air, $\mu = 1$. So it will be concluded from the above expression that if an air gap about 1 mm. exists in a magnetic circuit, the flux will fall to a fraction of that in the magnetic circuit, which has no gap.

If the permeability is constant, the magnetism caused by the constant magnetic lines of force (or magnetic flux) will be constant through the whole length of the test piece concerned, but if the test piece has a fault anywhere and the permeability is not constant, the constant intensity of magnetism will be broken at such faulty portion, where the leakage of the magnetic line of force will occur. So, if an exploring coil fitted to the specimen as shown in figures 6 and 7 is slided along the length of the specimen and induced current then produced in the coil is measured by means of the galvanometer method, the leakage of magnetic lines of force will be determined. In other words, if the specimen (rail) is homogeneous, that is, the permeability is constant, through the whole length and the leakage magnetic flux is constant, there will be produced no induced current in the exploring coil and the galvanometer mirror will not be deflected; while on the other hand, if there is a fault anywhere in the specimen and the uniformity of leakage magnetic flux is locally broken, induced current produced in the exploring coil will cause deflection of the galvanometer mirror, so that by measuring along the whole length of the specimen the induced current so produced in the coil, any defects in the inner part of rail will be detected.

Here let the time variation of magnetic

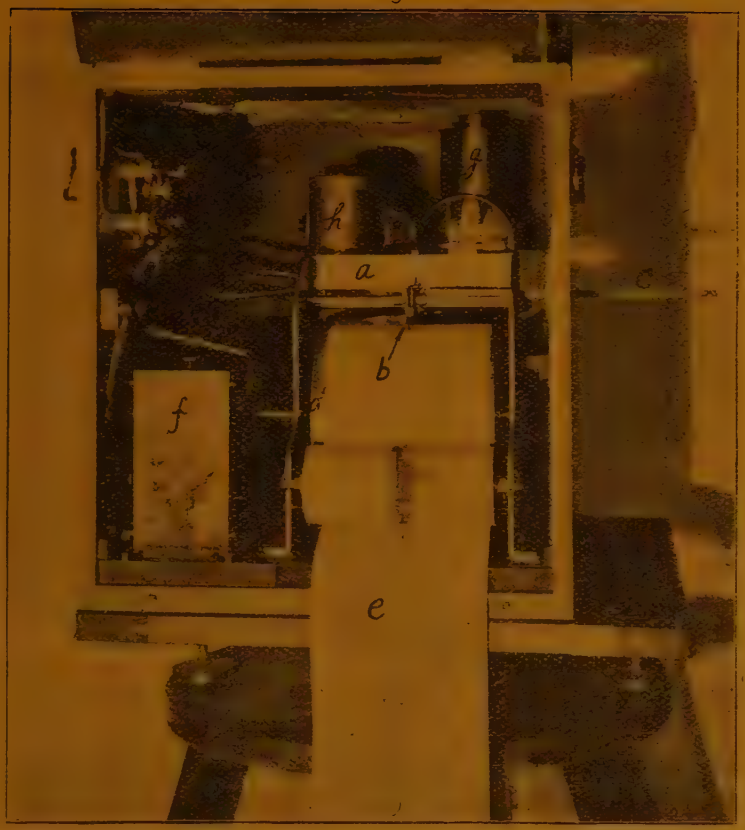


Fig. 5. — Detailed view of the recording apparatus.

LEGEND : a = Frosted glass. b = Pen-holder. c = Pen handle. d = Recording drum. e = Recording paper. f = Clockwork. g = Galvanometer. h = Light source.

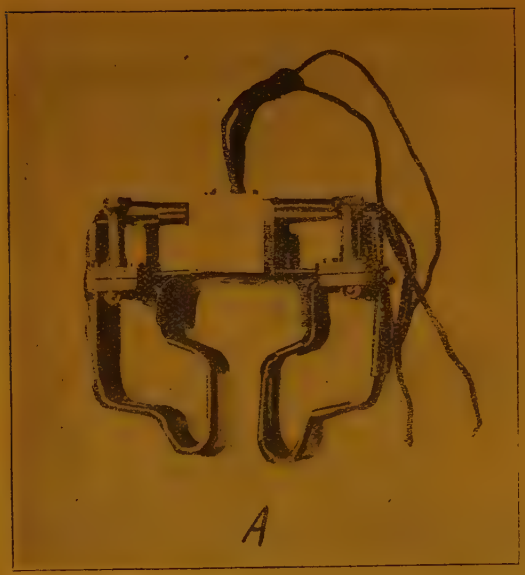
flux, that is, the rate at which magnetic leakage flux is cut by the coil, be denoted as $\frac{d\Phi}{dt}$, and the number of turns of the exploring coil as n, then the induced electro-motive force, E, produced in the coil will be as follows :

$$E = \frac{-1}{10^8} n \frac{d\Phi}{dt} \text{ in volts.}$$

In other words, the induced electro-motive force is determined proportionally to $\frac{d\Phi}{dt}$ and the number of turns of exploring coil n. Therefore, the induced current, i, flowing through the coil, is as follows :

$$i = \frac{E}{R} = -\frac{10^8 n \frac{d\Phi}{dt}}{R}$$

where R represents the resistance of the circuit.



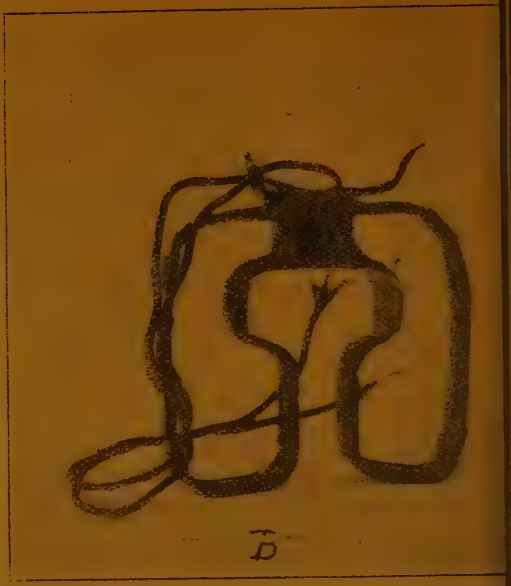


Fig. 6. — (*A* and *B*) : Exploring coil (laboratory type).

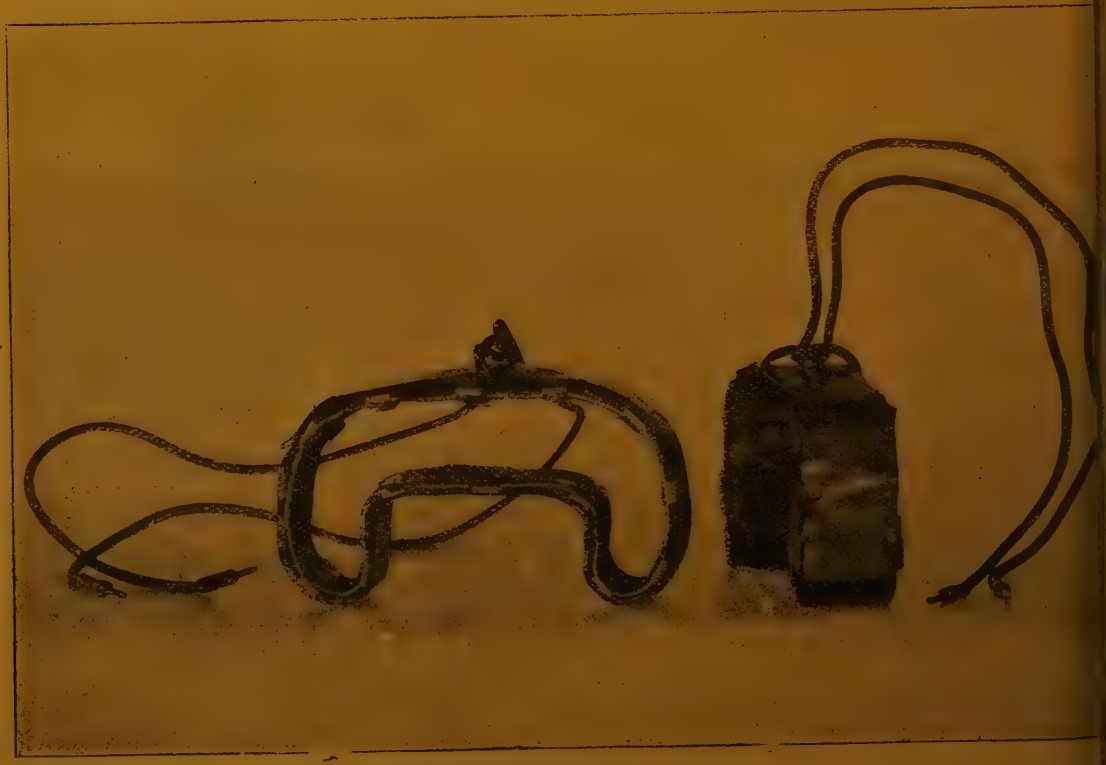


Fig. 7. — Exploring coil (track type).

It will be seen from the foregoing that the induced current varies with the number of turns of the exploring coil n and with the rate of the exploring coil cutting the leakage flux $\frac{d\Phi}{dt}$. It is, therefore, necessary that the magnet and the exploring coil should be moved at a uniform speed and the speed of cutting flux should be constant.

For magnetizing the rail, an electro-magnet of horse-shoe type is placed on the rail and is slided from one end of the rail to the other. Slightest air gap, therefore, between the rail surface and two poles of the electro-magnet, yes, even as little as one millimetre, gives so great an effect upon the magnetization of the rail, that scrupulous care must be taken to keep a uniform air gap between them.

With carbon steel such as rail steel, the maximum permeability occurs at a spot with magnetizing force of ten gausses, so that effort was made in the present study to magnetize the rail up to 10 gausses.

Figure 1 shows general view of the apparatus based upon the above mentioned principle for detecting faults in rails. At each of the two poles of the horse-shoe magnet (B), were fitted four rollers, so as to facilitate the slide of the magnet, detailed view of the magnet being shown in figures 2 and 3. Halfway between the two poles of the magnet is fitted an exploring coil (see figures 6 and 7) on rail and was slided along the rail as the magnet moves. This exploring coil consisted of very fine copper wire wound with silk and was completely insulated with mica plate, which was intended to provide against any leakage of external current affecting the coil; lead wires extended from both ends of the coil and so connected the coil with terminals of the galvanometer. On account of form of this coil as shown in figures 6 and 7, it was not affected by magnetic lines of force (magnetic flux) passing through the rail, but exclusively affected by leakage magnetic flux in the air surrounding the rail. The coil as shown in the figure 6 has a form convenient to handle in rail manufacturing shops or laboratories, and that as shown in figure 7 is better for rails already laid on track. As to examination of rails, this apparatus was fitted to the rail, so that a part of the rail might always be magnetized by an electric current flowing through the magnet. Then the apparatus was slided at a uniform speed from one end of the rail to the other by means of an electric truck (A, fig. 1). If there is any crack, cavity or blow-hole, abnormal stress or any such kind of fault in rail as may affect the magnetism or permeability, the galvanometer mirror will deflect, which is due to induced current in the exploring coil produced by leakage of magnetic lines of force. Figure 5 shows the detailed view of the recording apparatus used in our defecto-scope. The galvanometer used in our test was a d'Arsonval type having high sensitivity and quick damping. As for observation of the deflection, light ray coming from a light source (h, fig. 5) was reflected upon the mirror and the image of the reflected ray was formed upon frosted glass (a, fig. 5), which was placed some 30 centimetres (1 foot) in front of the mirror. In this way, the oscillation of the mirror was followed by shifting of the image.

Figure 4 shows the detailed view of the recording device. In figure 4 an operator has the pen holder (b), traces the reflected image of the light spot, coming from the galvanometer mirror and moving to and fro on the frosted glass (a),

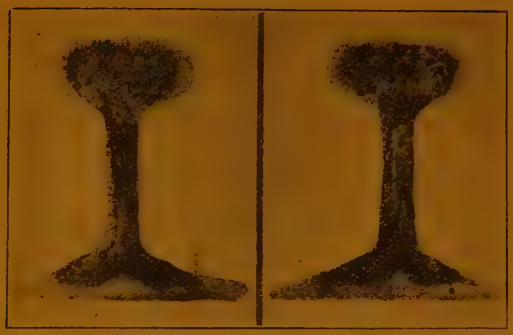


Fig. 8. — Comparison of sulphur prints.
Right hand : faulty portion.
Left hand : faultless portion.

Fig. 9. — Comparison of content of sulphur between fa
portion (B) and faultless portion (E). (Etched
5 % NO^3H alcohol solution).

Fig. 10. — Comparison of sulphur prints.
Right hand : faulty portion. — Left hand : faultless portion.

Fig. 11. — Cavity at the faulty portion (B)
of fig. 9.

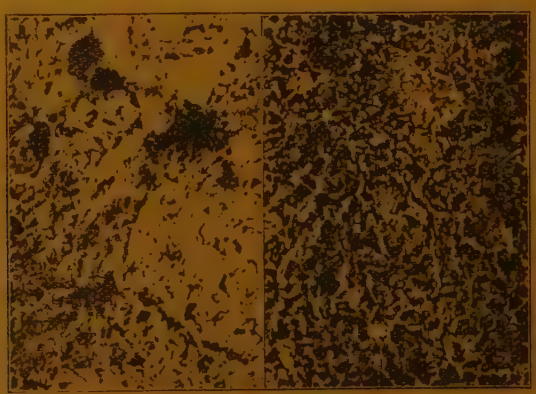


Fig. 12. — Microscopic structure at faulty portion.
Right hand : structure of head. — Left hand : blow hole and slag at the base.

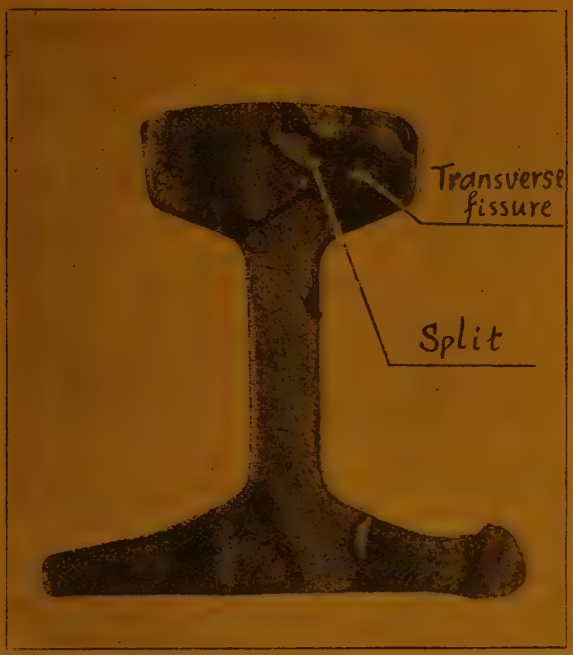


Fig. 13. — Intersection of transverse fissure
and split head, detected with the new rail defecto-scope in field survey.

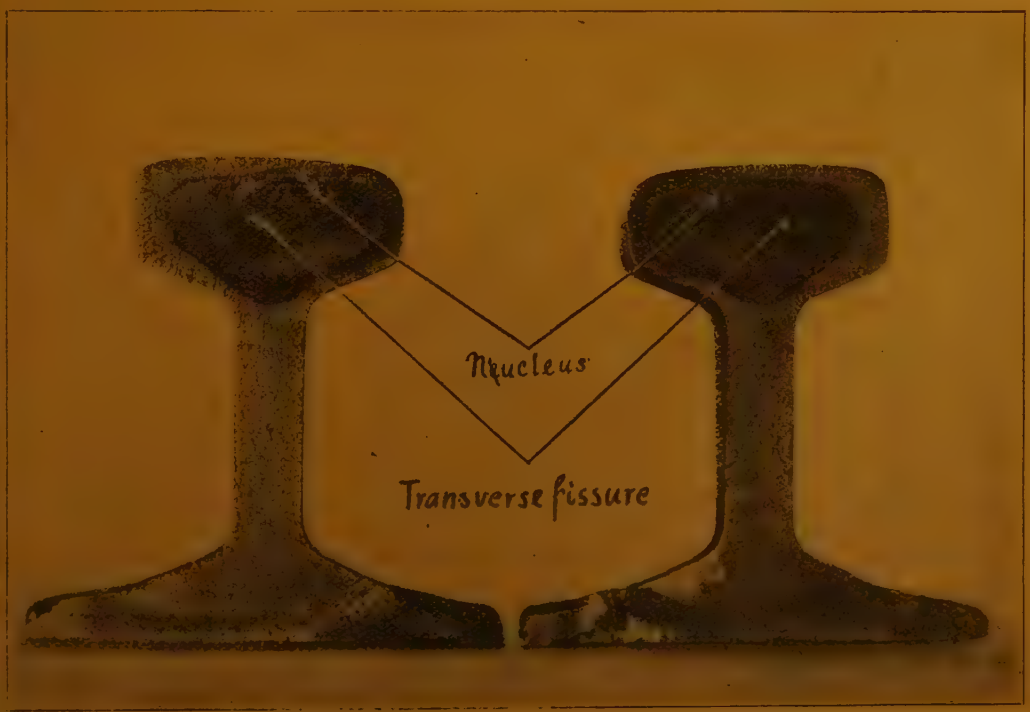


Fig. 14. — Transverse fissure detected with the new rail defecto-scope in field survey.

along a horizontal beam by means of a pen handle (*c*), and a pen attached to the lower end of the holder records the movement of the light spot on the recording paper (*e*) which is gradually drawn out by clockwork.

Figure 15 shows examples of curves recorded by our recording device for various rails. For perfect recording of the deflection of galvanometer, photographic film might have had an advantage over the recording paper (*e*, figs. 4 and 5) in point of accuracy and good appearance of result recorded. But the latter was adopted as it was very easy to handle and it made clear the defect readily on the spot, on track as well as in the laboratory.

Of the data concerning the apparatus, the following may be mentioned :

Electro-magnet :	
Dimensions of the horse-shoe magnet	38 × 38 × 735 mm.
Distance between two poles	205 mm.
Magnetizing force	4 000 ampères-turns.
Voltage of magnetizing	12 volts.
Current of magnetizing	2 amperes.
Total number of turns of magnetizing coil	2 000.
Size of magnetizing coil wire	No. 14, B. W. G.
Air gap between the pole of magnet and rail	0 mm. 5.
Exploring coil :	
Total number of turns	100.
Size of coil wire	No. 36, B. W. G.
Resistance of coil with leading wire	50 ohms.
Galvanometer :	
Manufacturer	Lead & Norshrup, U. S. A.
Type	d'Arsonval type, type R. No. 2500.
Period	6 seconds.
Sensitivity	0.0005 microampere.
Truck (magnet driving equipment) :	
Direct current motor	1 H. P., 48 volts, 10 amperes, 1 000 revolutions per minute.
Electric source	G. S. storage battery 80 amperes-hours.
Number of batteries	24 cells.

Figure 15 shows typical curves recorded for homogeneous and non-homogeneous rails.

(1) is a curve for fissured rail such as with transverse fissure, the deflection of galvanometer being large and rapid.

(2) is a curve for homogeneous rail, no remarkable deflection being seen, except that caused by initial movement of the magnet.

(3) is a curve for a rail of which a defect is exposed and of which the internal stress is not uniform.

(4) is one for a new rail, large deflec-

tions at equal intervals being due to stress at the spots pressed by a rail-straightening machine (or gagging press), the deflection of galvanometer being large but slow. The initial disturbance which is common to all is caused by tumult and residual magnetism in the rail due to the magnet at the time of starting the truck.

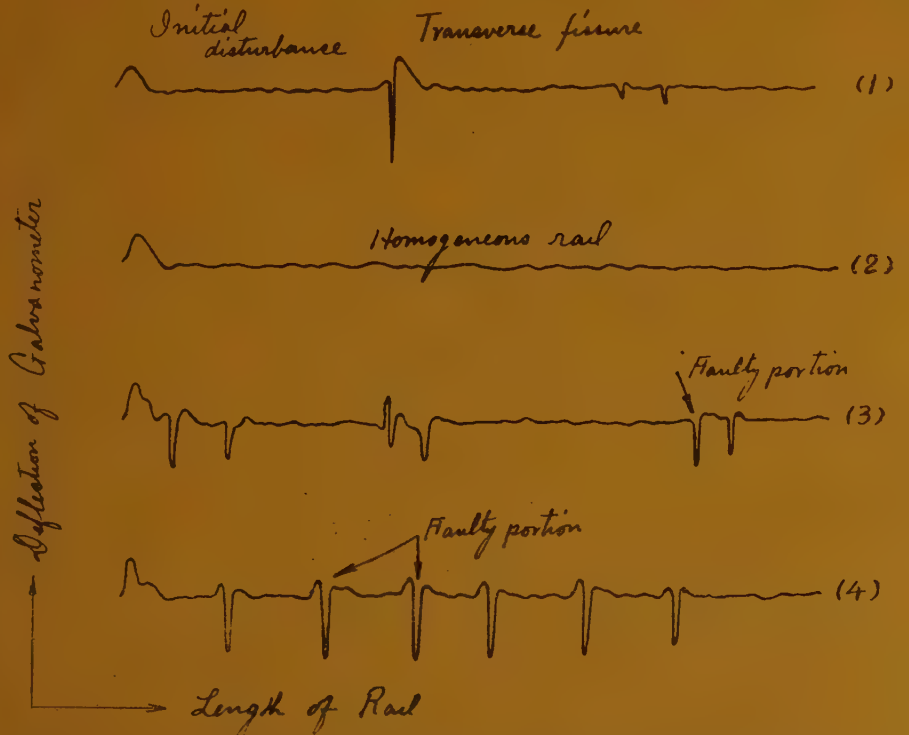


Fig. 15. — Comparison of the recorded curves between homogeneous and non-homogeneous rails.
(1), (2) and (3) are 60 lb. old rails, 33 feet long.
(4) is a 60 lb. new rail, 33 feet long.

III. — Results of experiment.

As preliminary experiment of the present study, artificial defects were given to rails by means of saws, drills, etc., for which curves recorded are given in figures 16 and 17 (rail Nos. 1 and 2). Galvanometric deflections due to transverse sawcut were large and rapid. These deflections are different in kind from other gradual ones (due to the effect of cold work, heat treatment, etc.) and may easily be distinguished from the latter.

It this way, about 100 rails were tested during the period September 1921 to the end of March 1922. Following is a comparative test carried on structures at faulty and faultless portions of rail as represented by curves of large and small deflections recorded on the paper. If the

results of rail break test show defects in the former and not in the latter, this apparatus may be said to be a proper one for detecting internal defects of various iron and steel materials such as rail. Now, in the break test, segregation of impurities, especially of sulphur, carbon, etc., and in-uniformity were examined by sulphur printing and microscopic testing, and at the same time, mechanical tests, such as hardness test, drop test and other testing by cut were carried out.

Rail No. 3 (fig. 18) was an old rail of foreign manufacture, 2 metres (6 ft. 6 3/4 in.) in length. As a large deflection was recorded at the middle of the rail, the rail was broken by rail bender, but no defect was visible to the naked eye. Also in the sulphur print as shown in figure 8 no remarkable difference was seen between the spots with and without defect. Further, in-uniformity of carbon was not found in microscopic test on the same test pieces. Finally, Shore's scleroscopic testing showed averages of 24 and 19 at the spots with and without defect, respectively, thus the difference being five. So, this great difference in hardness was regarded due to abnormal stress applied from outside at the time of certain cold working.

Rail No. 4 (fig. 19) was one which had been laid on track a few years. The piece tested was 160 cm. (5 ft. 3 in.) long. The comparative sulphur content at the spots with and without defect is shown in figures 9 and 10. The spot marked « B » of figure 9 is the section corresponding to N. 4, the content of impurities being far greater than at the faultless portion « E ». « A », « C » and « D » show the content mainly of sulphur at different spots (each approximately 1 cm. [3/8 in.] apart from « B »), where impurities were also found locally segregated. Further, cut-test made upon the portion corresponding to « B » showed a shrinkage cavity as is seen in figure 11.

From what has been said above, readers will see that segregation of sulphur, cavities, blow holes and increase in hardness due to abnormal local stress in rails must entail remarkable deflection of the galvanometer, and this deflection reversely makes possible the detection of internal faults of rails. Again, examination into microscopic structures showed 0.1 % and 0.2 % of carbon near the cavity and at the faultless portion (fig. 11), respectively. It is highly probable that this hole was due to a shrinkage cavity in steel ingot, decarburization taking place near the cavity at high temperature at the time of steel ingot being made.

As to the reason for the difference in hardness between faultless and faulty portions, rails, when rolled, generally bend to some extent, and these are made straight by pressing with the straightening machine; in the present test, these rails showed a large deflection at the spots so pressed; in other words, the deflections can safely be attributed to great local abnormal stress due to press, and high hardness at these spots may be regarded as effect of cold straightening work. This fact was corroborated by the experiment on rail No. 5 (fig. 20).

Rail No. 5 (fig. 20), was a new one, 4 metres long (13 ft. 1 1/2 in.). From the recorded curve two faulty portions may be inferred to exist near the middle, not to say the remarkable deflections at rail ends which were due to local heating. Two drop-test pieces, each 122 cm. (4 ft.) long were cut off the faulty and faultless portions, and they were named No. 3A and No. 3B, respectively. On these were made the drop-tests by dropping a

1 000 kgr. (2 200 lb.) iron weight from a height of 4.5 m. (14 ft. 9 in.). Deflection for 1 m. (3 ft. 3 3/8 in.) span as indicated in the annexed table resulted, but both pieces did not break. Further, Shore's scleroscopic and Brinell's hardness testings were made upon the same two pieces, as the result of which averages of 32 and 211.5 at the faulty portion and 28 and 204.5 at the faultless portion were obtained for Shore's and Brinell's respectively. As the microscopic structure showed almost no difference between faulty and faultless portions, the large deflection recorded may be regarded as effect mainly of press by the straightening machine.

By comparing the results of several hardness tests, it was found that the faultless portion had uniform hardness, while the faulty portion had in-uniformity, very hard spots being often found mingled with less hard ones, which indicated the presence of abnormal internal stresses given to rail when it was manufactured.

Rail No. 6 (fig. 21) was a new one, 4 metres long. Results of the drop-test on the test piece (No. 7A) taken from faulty portion and that (No. 7B) taken from faultless portion are given in the annexed table. No. 7A did break but No. 7B deflected about 70 mm. (2 3/4 in.). Microscopic study showed that the content of carbon and manganese sulphide or other impurities of the one was about the same as that of the other, but generally, high carbon and slag inclusion as seen near the bottom of the faulty portion (see fig. 12) were regarded as one of the causes for break, and great stress due to application of the straightening machine, which is likely to cause cracks in structure, especially in case of high carbon steel, was considered to make a cause for breakage.

While the steel ingot for all these tested rails was a product by the Bessemer converter, that for rail No. 7 (fig. 22) was a manufacture by the Siemens open hearth.

Rail No. 7 was a new one, with no straightening machine applied. The curve for this rail shows practically no large deflection over the whole length and indicates the rail to be magnetically almost homogeneous. Drop-tests were made on two test pieces, that is, No. 2′ and No. 2″ which were taken from two spots arbitrarily chosen of the rail. From the results given in the above table, we see that the second drop-tests made upon each of the two pieces caused no break. but deflection was well over 130 mm. (5 1/8 in.). The microscopic structure was also good, carbon and manganese sulphide or other impurities being uniformly distributed.

Rail No. 8 (fig. 23) was a new one made of Bessemer converter steel ingot. Results of drop-tests made on a test piece (No. 4A) taken from faulty spot and that (No. 4B) taken from faultless spot are also given in the above table. In the first drop-test, both pieces did not break, but in the second, only the faulty piece broke.

Thus it will be seen that although abnormal stress due to straightening press or gagging press cannot be said to be a defect in rail, at least so far as the manufacturing process at present is concerned, yet with our magnetic defectoscope, it is decidedly a defect. Such abnormal stress, indeed, gives no bad effect on the rail of low carbon steel, but it is likely to cause damage to comparatively high carbon one.

Results of drop testing.

Rail number.	Date.	Time.	Mark of specimen.	Content of carbon	Deflection		Discrimination by writer's defecto-scope.
					1st time test.	2nd time test.	
Rail No. 5.	March 8	3 p.m.	No. 3A	0.35 %	77 mm. 7	...	Faulty portion (a portion of large deflection).
	March 8	3 p.m.	No. 3B	0.35 %	74 mm. 6	...	Faultless portion (a portion of small deflection).
Rail No. 6.	March 10	3 p.m.	No. 7A	0.60 %	Broken.	...	Faulty portion (a portion of large deflection).
	March 10	3 p.m.	No. 7B	0.60 %	70 mm. 0	...	Faultless portion (a portion of small deflection).
Rail No. 7.	March 18	3 p.m.	No. 2'	0.35 %	77 mm. 0	139 mm. 7	Faultless portion.
	March 18	3 p.m.	No. 2''	0.35 %	71 mm. 4	130 mm. 2	Faultless portion.
Rail No. 8.	March 19	3 p.m.	No. 4A	0.40 %	70 mm. 0	Broken.	Faultly portion (a portion of large deflection).
	March 19	3 p.m.	No. 4B	0.40 %	64 mm. 0	122 mm. 0	Faultless portion (a portion of small deflection).

IV. — Results of tests upon rails laid on track on the Japanese Government Railways in Tôhoku (Northeastern) district.

Number of breaks of 60 lb. rails of foreign make and laid on track in 1887, on the Kôriyama Maintenance Section, Tôhoku (Northeastern) Main Line was not so much in summer as in spring and autumn. The total number of breaks was 12 in 1920, 20 in 1921 and 12 in the first six months of 1922. The breakage was regarded mainly due to the so-called transverse fissure which characterizes some of foreign made rails. From 20 to 27 July 1921, field-test was made with our apparatus on the rails which were laid on track between Sasagawa and Koriyama (136.3 to 139.4 miles from Ueno). The results showed that the majority were good as rail, but some of them had got lapping at the time of rolling process, which was no doubt due to poor ingot. In some case, this defect was visible from outside and in other, transverse fissure and split head were found intermingled (see fig. 13) with our apparatus. Rapid deflection at « A » of rail No. 9 corresponds to the defect shown in figure 13. It is noticeable that a clear nucleus crack is found in the fracture. Again, other deflection of the curve, judging from its slow movement, appears mainly due to stress given to the rail when it was manufactured.

Rail No. 10 was one taken out of track and stored on the premises of the Kôriyama Branch Office of Maintenance. Bend-test made on that portion of rail which corresponds to that of a large deflection of curve recorded, showed very clearly a typical transverse fissure (see fig. 14). In short, the internal transverse fissure, which gives the worst effect upon rails and is also one of the principal causes for simple breakage of rails laid on track for a long period, can clearly be distinguished from other defects on account of rapid shifting of the light spot caused by the former. But in rails where the nucleus crack has not grown large enough, the shifting of light spot is rapid but not large, which naturally requires scrupulous care in the observation.

V. — Principle of the new testing method applied to other test.

The foregoing is mainly a report on results obtained from 60 lb. steel rails. But the principle of such method of detecting faults by magnetic induction has much wider application. It may be used for examining all ferro-magnetic materials with uniform section, from those with larger section, such as bars, shafts, steel pipes, etc., down to those with smaller section, such as cable or wire-rope used as suspender of elevators or at mines. For more than ten years, study in this direction has been made by the Bureau of Standards, U. S. A., and of late an apparatus named « Cable Analyzer » has come into the market. This is somewhat different from ours, but no detailed report being given, we cannot ascertain to what extent defects may be detected with this device. It is gathered from the results of our rail examination, that the American apparatus will be of value for examination of bars, cables, etc., which have rather small section.

VI. — Summary.

This report deals with the typical of the results of many experiments. Rails recorded as faulty by our apparatus have also been proved so by other mechanical

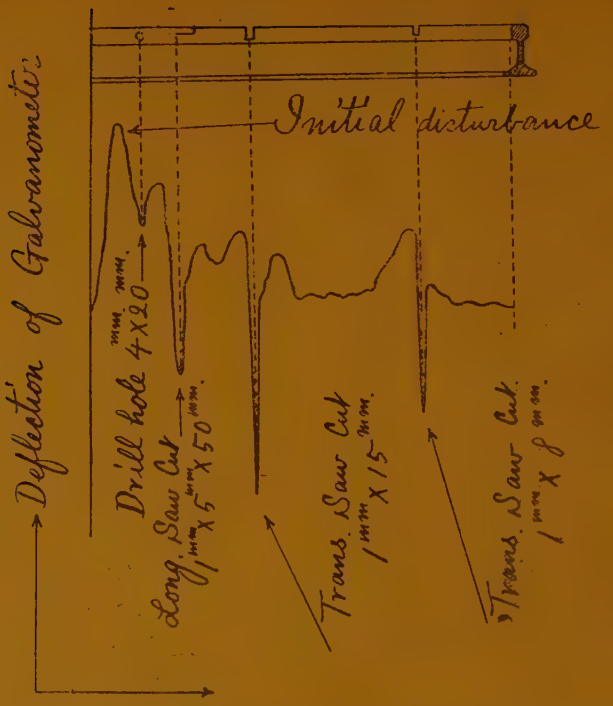

Deflection of Galvanometer
Initial disturbance
Drill hole 4 x 20 mm.
Long. Saw Cut 1 mm. x 5 mm. x 50 mm.
Trans. Saw Cut 1 mm. x 15 mm.
Trans. Saw Cut 1 mm. x 8 mm.

Fig. 16. — Rail No. 1 : A record for 60 lb. new rail, showing the effect of various artificial defects.

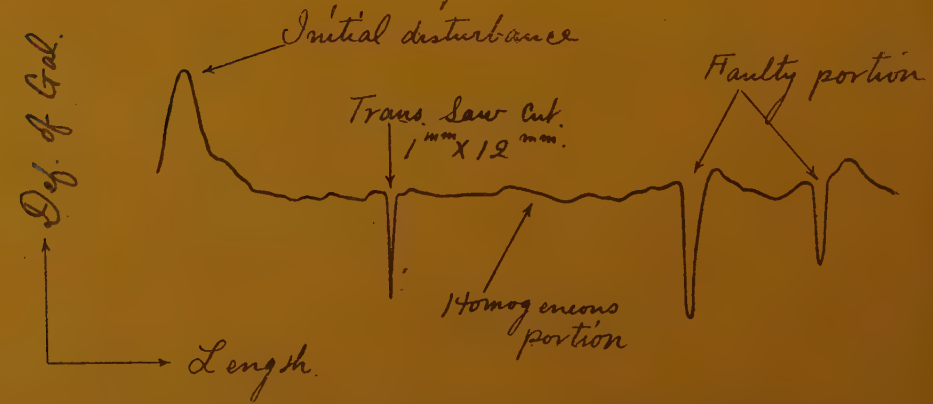


Fig. 17. — Rail No. 2 : A record for 60 lb. old rail, showing the effect of a saw cut and other faulty portions.

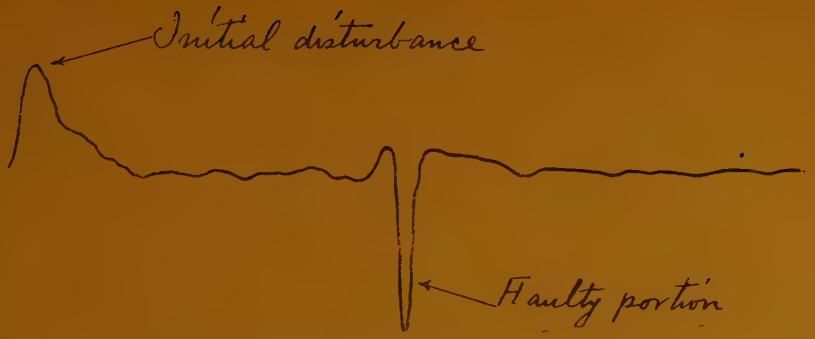


Fig. 18. — Rail No. 3 : A record for 60 lb. old rail, showing a faulty portion.

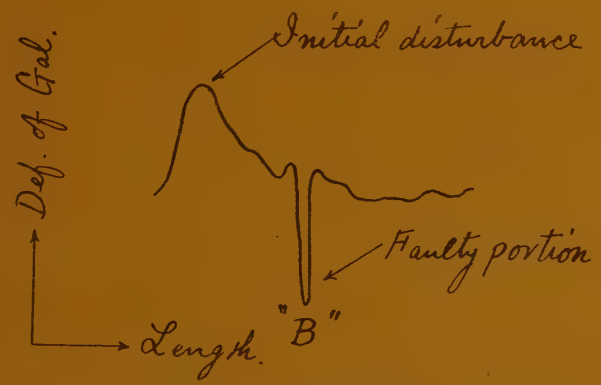


Fig. 19. — Rail No. 4 : A record for 60 lb. old rail, showing a faulty portion.

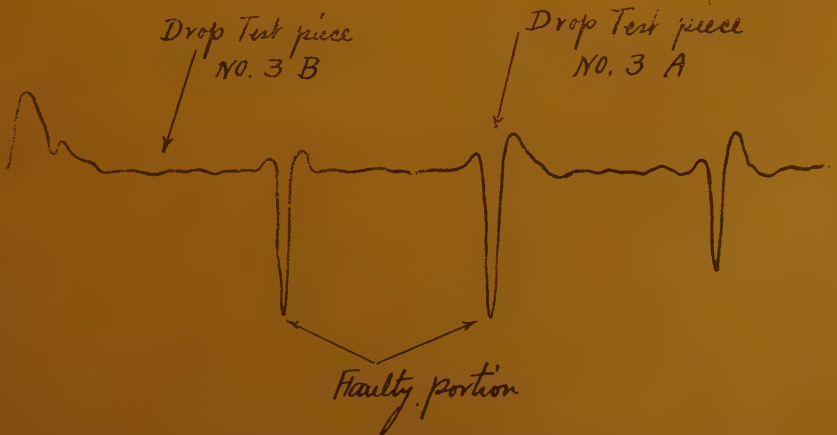


Fig. 20. — Rail No. 5 : A record for 60 lb. new rail, showing some defects.

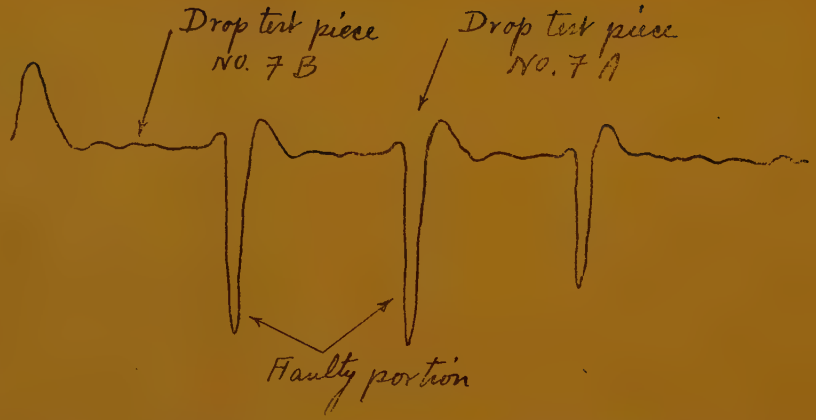


Fig. 21. — Rail No. 6 : A record for 60 lb. new rail, showing some defects.

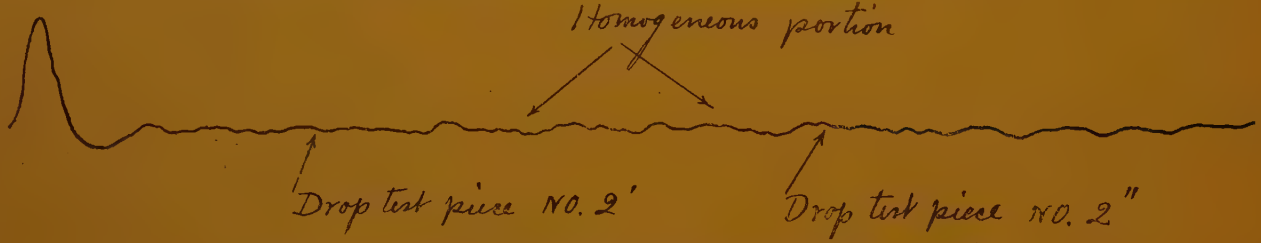


Fig. 22. — Rail No. 7 : A record for 60 lb. new rail, showing homogeneity.

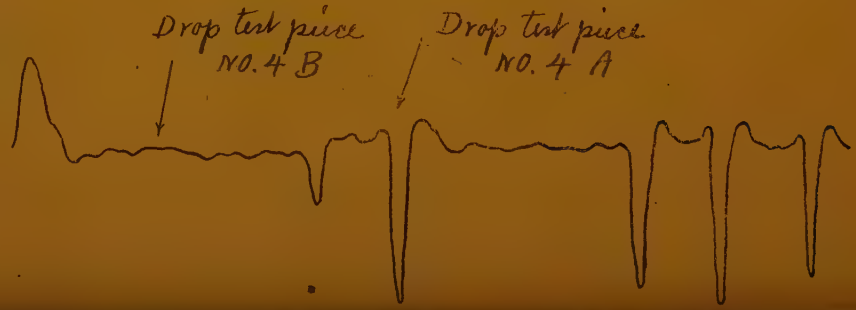


Fig. 23. — Rail No. 8 : A record for 60 lb. new rail, [illegible]

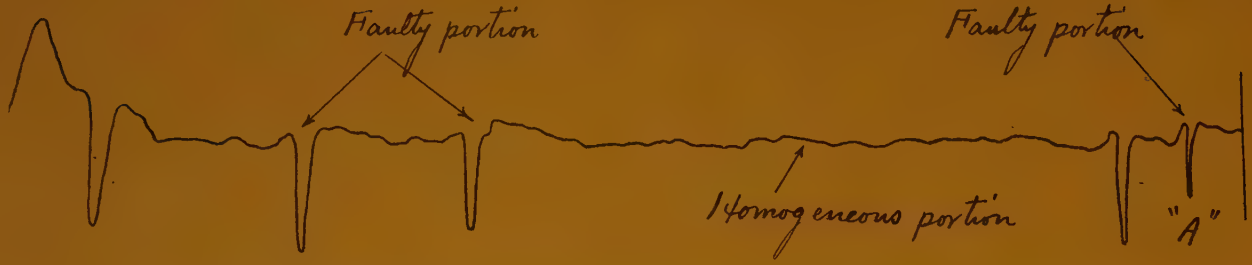


Fig. 24. — Rail-No. 9 : A record for 60 lb. old rail laid on track, showing some defects.

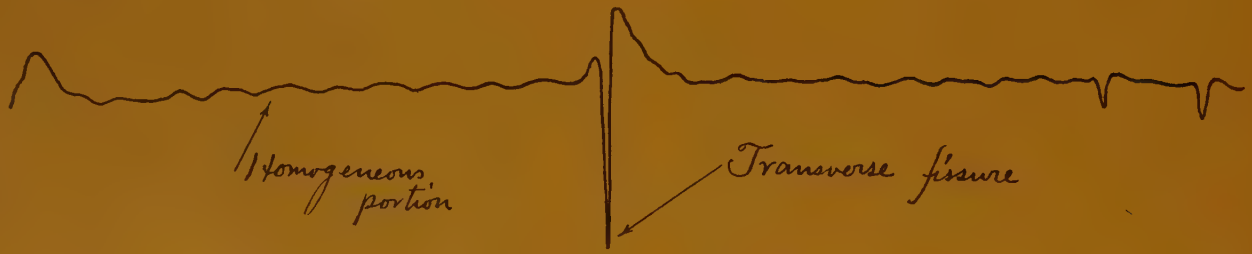


Fig. 25. — Rail No. 10 : A record for 60 lb. old rail, showing an abnormal deflection due to a typical transverse fissure.

tests. Further, according to the results so far obtained, three different kinds of internal defects of rail are detectable with our apparatus, that is :

1) internal cracks and cavities or blow holes,
2) segregation of impurities,
3) abnormal internal stresses (mostly due to press by straightening machine).

Of these three, deflection of galvanometer due to the first, being comparatively rapid, can be distinguished from slower ones due to other two.

The second, that is segregation of impurities is not, by nature, so high in degree as to make the affected rails necessarily unserviceable.

The last one, namely abnormal internal stresses, may be insignificant, if the carbon content be low; while if it is high, there will be risks of serious rail failure.

The merits of our device may be enumerated as follows :

1) Simplicity;
2) Distinctness and accuracy in detecting various defects, that is, curves recorded enable faulty portions clearly to be distinguished from faultless portions;
3) It is handy and portable, so that it may be applied on the spot to rails already laid on track as well as rails just purchased and not yet in service;
4) Test on one rail is completed in a rather short time. With our apparatus, the time required for testing one rail is about one or two minutes. Where rails can easily be handled or have already been laid on track, the number amounts to about 100 in an hour.

[385. (09.1 (.45 + .494)]

The Domodossola-Locarno Italian-Swiss Railway.

Figs. 1 to 9, pp. 346 to 355.

(*Rivista tecnica delle ferrovie italiane.*)

After being eighteen months in operation, the Domodossola to Locarno Railway has proved to the public at large its importance from the international point of view as a link between the St. Gothard and Simplon lines, as well as for the economical life of the numerous valleys which it serves, but especially for the interest it offers to tourists on account of the characteristic aspects of the wild and picturesque valleys over which it passes and the table land of Vigezzo covered with green meadows. On the other hand, this period of working has shown, from the technical point of view, the best commentary as to the success of several bold conceptions and the advantages of electric traction under the most unfavourable conditions for the construction of a railway.

Now that it is possible to form a settled opinion on the subject, it seems a favourable time to publish the following article on the new line, which has already been described (1), from particular points of view, without giving, as is our intention, the original photographs as a guide, for which we are indebted to the courtesy of the « Società Subalpina di Imprese Ferroviarie », and which show the most interesting constructions, both in metal and stonework on the line.

(*Note by the Editor of the « Rivista Tecnica ».*)

* * *

I. *General remarks.* — The designers of this railway were naturally anxious to keep intact, as far as possible, the natural beauties of the scenery, and did their best to give to the various constructions the design most suitable for the majestic wildness of the country, and as we shall see, they succeeded perfectly in their task.

The survey of the new line, which was commenced on the Italian side in 1904 through the initiative of Vigezzin Andrea Testore, and on the Swiss side by that of the Hon. Francesco Balli, met with continual difficulties, either of an administrative nature, two states being involved, or by economical matters relating to the financial organisation of the scheme, so that everything was held back until the 27 May 1911, when the construction of this new railway was placed in the hands of the engineer, Jacques Sutter. In February 1912 the « Società Subalpina di Imprese Ferroviarie » (Subalpine Company of Railway Construction) was formed at Milan, which took the place of the concession given to Engineer Sutter, and after having successfully completed all arrangements for the scheme, started work in December of the same year. The European conflagration, however, considerably upset the work, which at first

(1) See the article in the *Schweizerische Bauzeitung* for 1922 : « Die eisernen Ueberbauten der Centovalli-Bahn, Ferrovia Locarno-Domodossola » (Metal structures on the Centovalli Railway), by Engineer P. Sturzenegger, and the article in the *Rivista dei Trasporti* for 1924 : « La ferrovia elettrica Domodossola-Locarno ».

Fig. 1. — Viaduct over the valley of Margologio (10th km.) 3 arches of a span of 29 m. (95 feet) and 56 m. (184 feet) above the bed of the river. The view shows a through train passing over.

Fig. 2. — Bridge over the Antoliva valley (14.05th km.) composed of one arch of 46 m. (151 feet) span and four arches of a span of about 6 m. (20 feet) each. About 50 m. (164 feet) above the bed of the river.

was slowed down and then entirely stopped, to be recommenced in 1920 and happily finished in 1924.

II. *General plan.* — The new railway leaves Domodossola at an altitude of 270 m. (886 feet) above sea level, crosses the valley of Ossola, climbs along the valley of Vigezzo up to the plateau of the same name (altitude of the station Santa Maria Maggiore which corresponds to the dividing line of the waters: 820 m. [2 690 feet]) and from thence descends along the valley of Melezza, called Centovalli, up to Camedo (on the Italian-Swiss frontier). At this point, near Ponte Brolla, it rejoins the Locarno to Bignasco railway, over which it runs for a distance of 5 km. (3.1 miles), finally reaching the Swiss Federal Station of Locarno. The complete plan is shown in figure 7.

The gradients on the Italian side average 1 in 36, and about 1 in 50 on the Swiss side; the steepest gradient being 1 in 16 and the sharpest curve has a radius of 50 m. (2 1/2 chains). The total length of the line is about 46 km. (29 miles), of which 32 km. (20 miles) are on Italian

Fig. 3. — The Ruinacci metal bridge (Swiss section). Main arch of 58 m. (190 feet) span with two end spans of 21 m. (69 feet) each. Height above river bed : 55 m. (180 feet).

territory and 14 km. (9 miles) in Switzerland, which include the 5 km. (3.1 miles) in common with the Locarno to Bignasco Railway. The population in these valleys amounts to about 6 000, but a population of more than 30 000 is directly interested in this line.

The railway is supplied with Vignoles

rails weighing 25 kgr. per linear metre (50.4 lb. per yard), and is used by passenger and goods trains, which accomplish the distance in about two hours. Through trains are also run to establish the connection between the fast trains from the Simplon to the district of Lake Majeur.

III. *Structures.* — With the exception of the crossing of the plateau of Vigezzo, and over a few kilometres on the plain of

Fig. 4. — Bridge over the Isorno near Intragna (Swiss section). The main arch has a span of about 87 m. (290 feet) with two others, one at each end respectively of 16 m. (52 1/2 feet) and 25 m. (82 feet). Height above the bed of the river : 75 m. (246 feet).

Toce, nearly the whole length of the line is made up of an uninterrupted series of bridges, viaducts, sustaining walls and also, especially on the Swiss side, numerous tunnels.

On the Italian section there is only one metal construction which crosses the river Toce, near Domodossola; the most important structures being of stonework, namely:

a) the Margologio viaduct (fig. 1), with three arches of a span of 29 m. (95 feet) and about 56 m. (184 feet) above the bed of the torrent of the same name

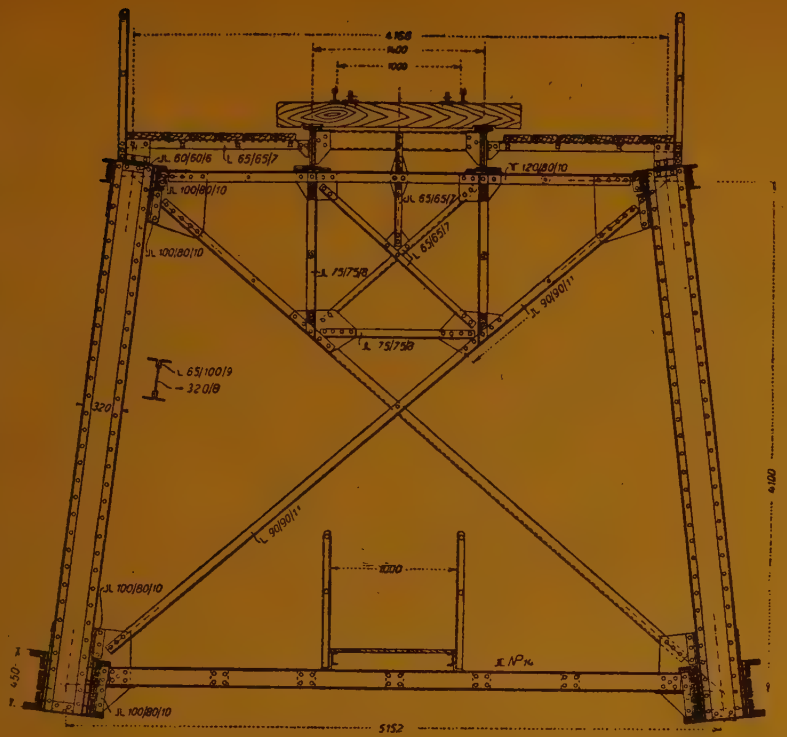


Fig. 5. — Cross section of the bridge over the Isorno (scale 1/60).

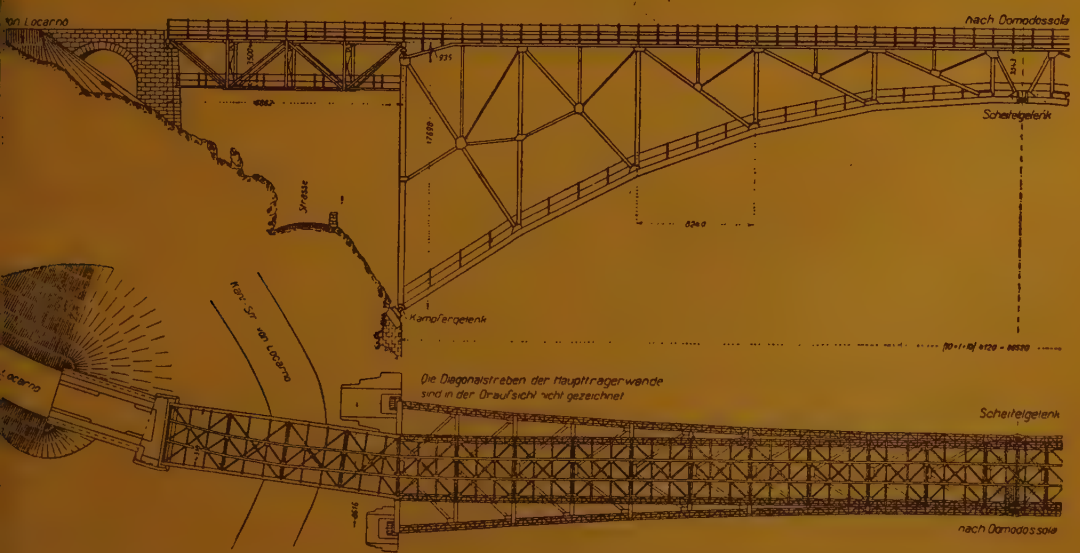
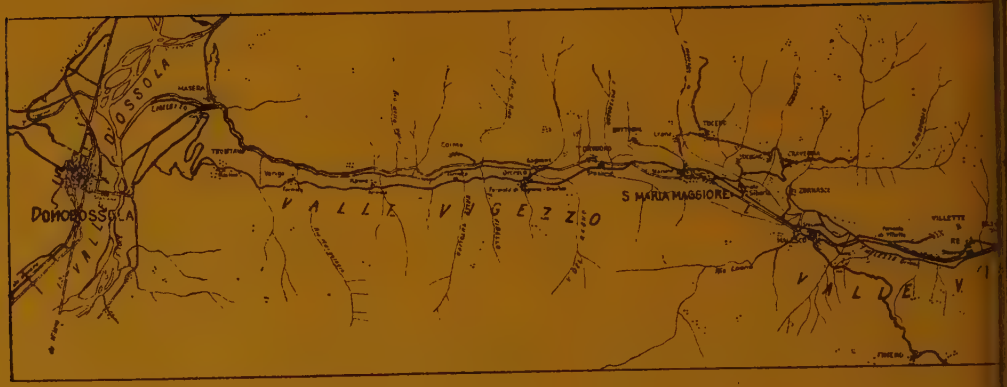


Fig. 6. — Half elevation and plan of the bridge over the Isorno on the Locarno side.

Explanation of German terms: Die Diagonalstreben der... = The diagonals of the main girders are not shown in this view. — Kampfergelenk = Hinge at the springing. — Kant-Str. = Cantonal road. — Nach Domodossola = Towards Domodossola. — Scheitelgelenk = Hinge at the key of arch. — Strasse = Roadway. — Von Locarno. = From Locarno.

Scale



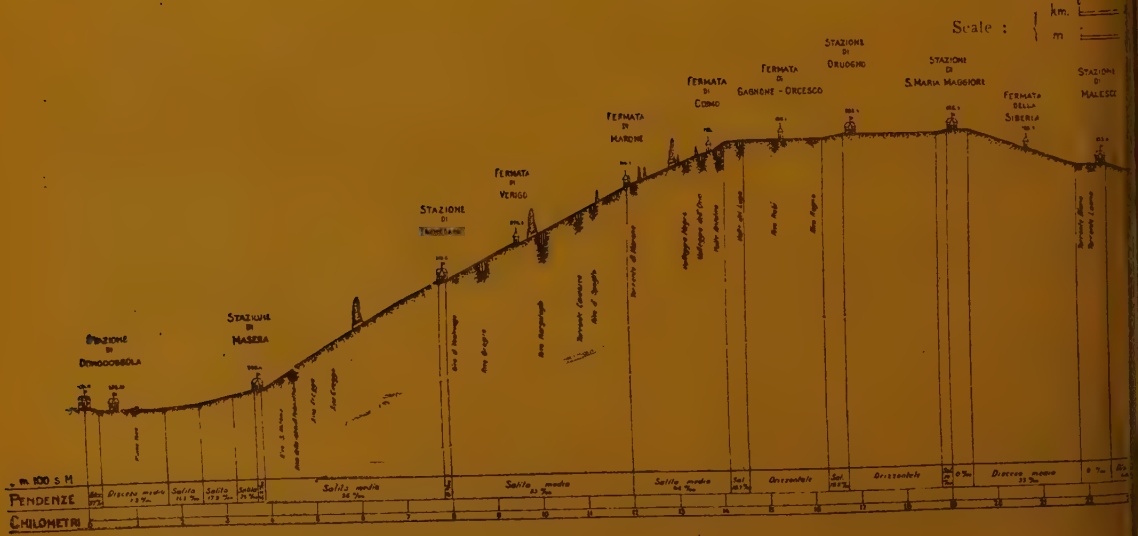
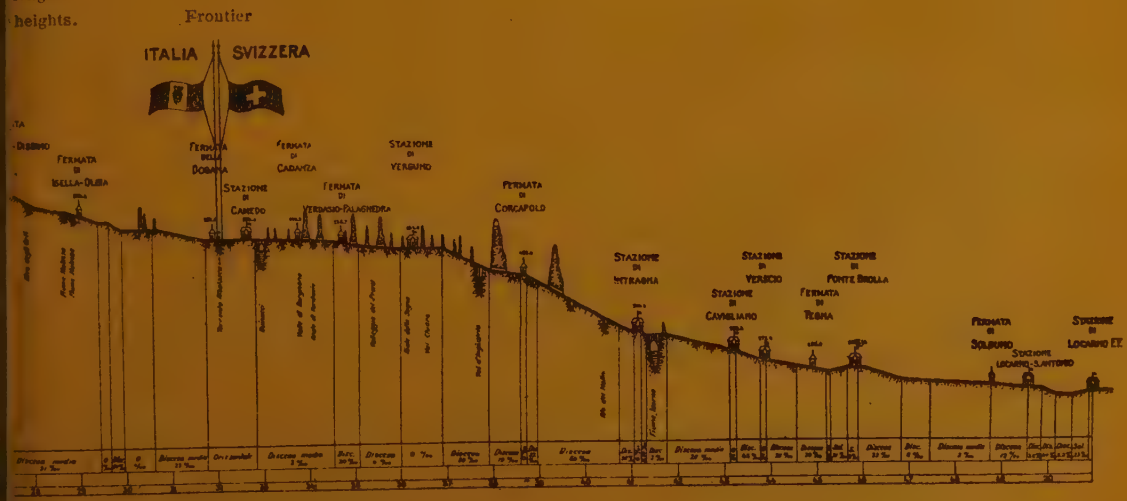


Fig. 8.

Explanation of t

lengths.
heights.



ric lines.

= Stopping place.

and near the 10th km. its gradient being about 1 in 19;

b) the bridge over the Antoliva (fig. 2) is composed of one arch with a span of 46 m. (151 feet) and four arches of a span of about 6 m. (20 feet), and is 50 m. (164 feet) in height above the bed of the stream situated near the 14th km. on a gradient of 1 in 112;

c) the Cutredo viaduct, over the Melezza torrent, is composed of five arches of a span of 16 m. (52 1/2 feet) and one arch with a span of about 12 m. (39 1/2 feet).

On the other hand, the Swiss section has only one construction in stonework of any importance, this being the viaduct over the valley of Ingiustria, and composed of three arches of 25 m. (82 feet) span and one of about 12 m. (39 1/2 feet), its height being about 60 m. (197 feet).

It is worth while pointing out, both from design and constructional points of view, that the two metal bridges, both on Swiss territory, have gradients of 1 in 333, one of which is in the district of the Ruinacci near the 33rd kilometre close to the frontier, and the other over the Isorno torrent at the 41st km. The engineers in charge of the design of these two structures did their utmost, and with great success, to make the design suitable for the picturesque framing formed by the deep, verdant and wild valleys. The bridge over the Ruinacci (fig. 3) is composed of a central span of about 60 m. (197 feet), and a span at each end of 21 m. (69 feet) each, its height above the river bed being about 197 feet. The bridge over the Isorno (fig. 4) is composed of a central arch of about 90 m. (295 feet) span and one at each end of 16 and 25 m. (52 1/2 and 82 feet) respectively. The height above the river bed being 75 m. (246 feet).

The central arch of both bridges is hinged at three points, whilst the end spans are simply supported at their extremities.

The uniform character of the general arrangements of these two bridges was influenced by the local conditions, besides making the construction of the framework easier and more economical, as well as for their erection.

As regards the characteristics of the line over these two bridges, it should be mentioned that it is straight over the central arches and curved over the end spans to a radius of 300 m. (15 chains). The total length of the first bridge is 128 m. (420 feet) and that of the Ruinacci 99 m. (325 feet). The main girders of the two bridges are inclined to one another at an angle of 1 in 8.3 (see fig. 5), and the distance between them at the top is 4.166 m. (13 ft. 8 in.), a figure which represents respectively 1/20 and 1/15 of the spans of the two bridges. The height of these girders at the key is 3.50 m. (11 ft. 5 3/4 in.), or about 1/25 and 1/19 of the respective supports. The proportion of the distance between the points of support and the elevation of the arch keys above the springing of the arches is about 6 to 1 for the Isorno bridge, and about 4 to 1 for the Ruinacci bridge. Figure 6 shows in elevation and plan half of the Isorno bridge, which taken in conjunction with figure 5, gives some interesting constructive details.

IV. *Rolling stock and composition of trains.* — Passenger and goods trains are run by similar motor coaches, the principal mechanical characteristics of which are as follows :

Length over buffers : 14.404 m. (47 ft. 3 1/8 in.);

Distance between the two bogie centres : 8.500 m. (27 ft. 10 3/4 in.);

Rigid wheel base of each bogie : 2.200 m. (7 ft. 2 5/8 in.);

Diameter of the driving wheels: 0.920 m. (3 ft. 1/4 in.) ;

Total adhesive weight : 30 t.

The buffer and traction apparatus is applied to the bogies, an arrangement which has been found to be very advan-

tageous for lines of steep gradients and sharp curves. Each motor coach contains a sitting accommodation for 36 passengers and for 15 standing; the trailers (generally two for each passenger train) weigh unloaded 11 t. each and have room for 41 sitting and 30 standing. With goods trains, wagons take the place of the two trailers, the tare of which is 7 t. and may be loaded to 5 t. each. In both cases the total weight of the complete train averages 65 t. and has a speed of 20 km. (12 1/2 miles) per hour on a gradient of 1 in 27, and 40 km. (25 miles) on the level.

V. *Electric equipment for the motor coaches and the line.* — The equipment of the motor coaches consists of four 110 H. P. motors working at a pressure of 1 200 volts continuous current, and at a speed of 630 revolutions per minute; also a controller with running positions in series and in parallel, and arranged for electric braking; two operating controllers; a pantograph current collector; an automatic single pole circuit breaker with hand and air control, and a motor compressor having a capacity of 550 litres (19 1/2 cubic feet). Whilst there are two driving controllers, one at each end of the motor coach, there is only one main controller placed in the high tenion chamber in the centre of the car. This controller is made up of a certain number of contactors worked by cams fixed on a central shaft; the latter in its turn being mechanically controlled from the two platforms of the motor coach.

The controller also contains a drum for reversing the running direction, and a drum for cutting out one of the two groups of two motors. The reversing drum can be controlled either pneumatically from the driving platforms, or by hand on the controller itself by means of a lever. On the other hand, the drum used for cutting out a group of motors can only be worked by hand on the controller.

The equipment of the motor coach also comprises a complex system of ingenious interlocking devices, mostly of recent design and designed purposely for this type of car, thanks to which mistakes that might be made in operating become almost impossible. For instance, if the reversing handle is pulled back on the operating switch, all controls remain inoperative, and it is not possible to reverse the motor coach or raise the pantograph or close the main switch unless the controller is in the « off » position; on the other hand, it is possible in all cases to open the circuit breaker or lower the pantograph. Entrance into the high tension chamber is not possible, unless the pantograph is lowered.

Control of the circuit collector (pantograph) is carried out pneumatically by means of the operating switches, and if the compressed air fails, the necessary supply can be given by means of a hand pump.

The contact wire, which is of copper of 80 mm² (0.124 square inch) section, is simply suspended on wooden posts fixed in iron sockets and reinforced concrete, and placed at a maximum distance apart of 35 m. (115 feet).

Figure 9 shows the arrangement of the electric distributing mains. Current is supplied by three sub-stations situated respectively at Trontano (km. 7.9 from Domodossola), at Re (km. 25.75) and at Ponte Brolla (km. 46), each of which is equipped with two groups of converters each one supplying 425 kw. of continuous current at a pressure of 1 300 volts. On the other hand, the sub-stations receive three-phase current at a frequency of 50 periods and a pressure of 12 000 volts at Trontano and Re, and 6 000 volts at Ponte Brolla. There is therefore available for working the railway an installed capacity of 2 550 kw., of which 1 275 kw. is in use, or sufficient power to run simultaneously two normally loaded trains on the steepest gradient which occurs on the track (1 in 16.6).

There are three feeders: the first start-

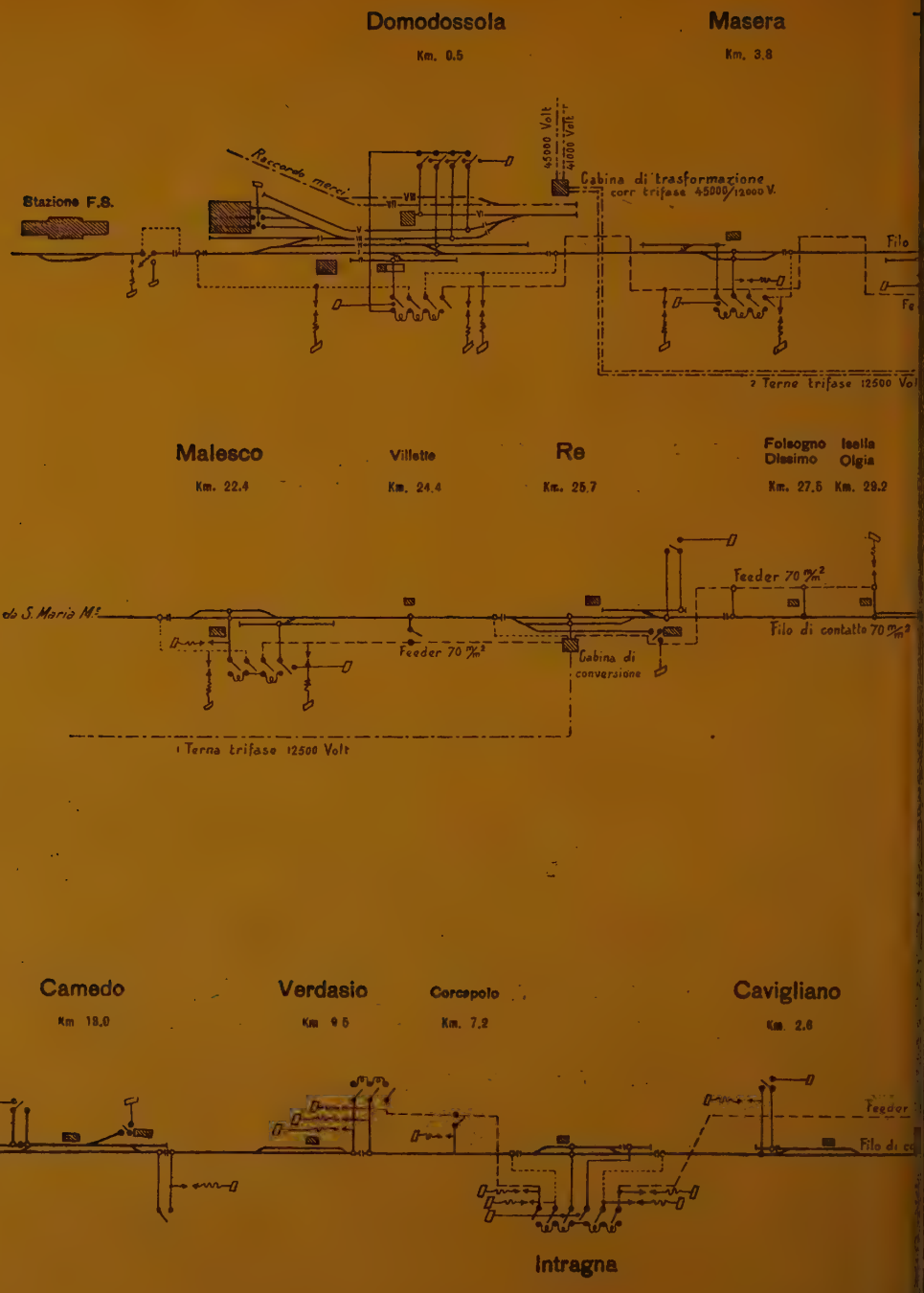
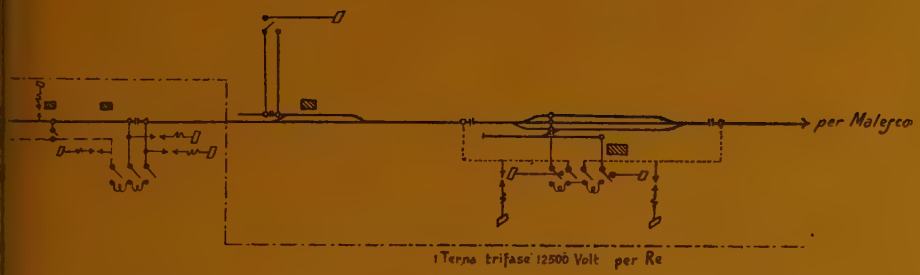


Fig. 9. — Dia

Translat

Marone Coimo Druogno S. Maria Magg.

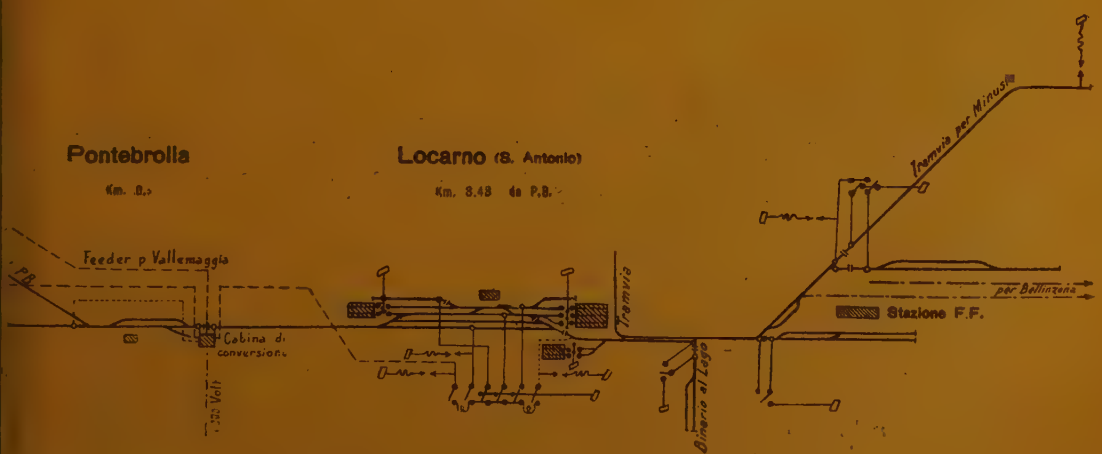
Km 12.0 Km. 13.8 Km. 16.9 Km. 19.1



LEGEND :

- Contact wire.
- Feeder wire.
- Junction wi e.
- Three-phase current wire.
- Section insulator.
- Overhead wire switch.
- Earthing switch
- Automatic contact maker.
- Lightening conductor with resistance.
- Self induction coil.

per Camedo



of the electric lines.

gana = Customs.

ing from the sub-station at Trontano, rejoins the contact line at Domodossola at the 13th km.; the second leaving the sub-station of Re rejoins the contact line at the 22nd km. and 30th km. and the third leaves the sub-station of Ponte Brolla and rejoins the contact line at the 35th km. and 46th km.

[625 .111]

The virtual coefficients of railway lines.

By Professor S. F. BALATRONI, of the Royal Engineering College, Bologna.

(*Rivista dei Trasporti.*)

1. — The determination of the *virtual lengths*, that serve as the basis for the calculations of the total costs of working, is based on statistics which, no matter how conscientiously they may have been compiled by the railways to which they relate, can only be applied with difficulty to other conditions of time and place, because the details of these costs, and, what is still more important, the relative proportions vary from time to time and from place to place.

The virtual coefficients that are deduced from considerations of the motive power consumed alone, without taking account of the make-up of the trains, do not take into account sufficiently accurately the full influence of the gradients, even when dealing with that portion of the costs of traction to which they are intended to apply.

The Italian formula (Italian Railway Conventions of 1885), which took account of the influence of gradients from the double point of view of the extent to which the make-up of the train is dependent on the maximum gradient and the extent to which the mean gradient modifies the consumption of motive power necessary for hauling the train, laid down a rational basis which was hidden by too many approximations and by the excessive number of mean values introduced into this formula. These made it appear to be an empirical expression rather than a formula based on rational data.

Many authorities, of whom probably the first was Professor Azimonti [1], recognised the good features of this first formula, and restored it to favour. Recently Professor Maffezzoli [2] gave it a rational and very simple form worthy of adoption with every confidence. We think it worth while reproducing this formula, in which we have substituted the notation that has been adopted by us for this article :

$$\lambda'_i = \frac{(1\,000\, f \frac{\delta}{w_0} - 1)\,(w_i + i)}{1\,000\, f\, \delta - (w_m + i_m)}. \qquad (1)$$

The constant gradient of the virtual line $i_0 = 0$.

f is the coefficient of adhesion.

w_0, w_i, w_m are the coefficients of resistance to traction on the level and on the straight at the speeds which, with the locomotive in question, correspond to those of the train on the gradients 0, i (mean) and i_m (maximum). Maffezzoli advises that these speeds and resistances be calculated by means of the empirical formulæ :

$$V = 48 - \sqrt{10\,(i - 9)}$$

and $$w = 1.2 + 0.02\,V + 0.0005\,V^2$$

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(1) « Alcune note sul confronto dei tracciati stradali... » (Notes on the comparison of the alignment of roads). Milan, 1907.

(2) « Le lunghezze virtuali e la formula dell' Allegato *F* delle Convenzioni ferroviarie italiane del 1885 » (The virtual lengths and the formula of Appendix *F* of the Italian Railway Conventions of 1885). *Rivista dei Trasporti*, 1924, No. 9.

where V (the speed in kilometres per hour) $= 45$, up to $i = 10$ mm. per metre.

δ is the ratio of the adhesive weight to the total weight of the locomotive.

We propose to investigate whether it is not possible, without excessive practical difficulty, to give the formula (1) with the necessary modifications, a more extended application by making an enlargement of the usual idea of the virtual length, which, on close examination, appears to be insufficiently wide. We shall, moreover, retain the feature of the virtual line of being on the level, that is to say : $i_o = 0$.

2. — In calculating the virtual length of a lay-out of a line a suitable type of locomotive is selected and supposed to run with various trains and often at different speeds both on the actual line and on the virtual line. The make-up of the train follows the requirements respectively, for adhesion, of the two gradients i_m and i_o. It is of little importance that the second of these trains could not be run on the virtual line, a hypothetical train alone being in question, as a basis of comparison, but not necessarily a train that would comply with the practical conditions.

If the lines that are to be compared have maximum gradients i_m (gradients by which we mean the ruling gradients that decide the make-up of the trains and not the short steeper gradients that can be surmounted at a run), which differ little between themselves, and if consequently they can be worked rationally by the same locomotive, this will only affect the value of the virtual coefficients; because the factor of comparison remains always the same for all lines (so far as they are purely hypothetical) and consequently the relative meaning undergoes no change. Nevertheless, the virtual coefficients arrived at have no fixed value, because they relate to hypothetical traction on a virtual line and this traction varies according to the locomotive that is adopted for the actual lines.

But when it is necessary to compare (as in the general and most usual case) lines having different maximum gradients, and consequently having their services properly worked by locomotives having different characteristic features, these virtual coefficients determined as above lose all their meaning, even their relative meaning, because for the object of comparison (for the virtual line) different types of traction are used in the different cases.

If, on the other hand, it were desired that this comparative term should remain the same, it would be necessary to assume that the same tractor was used on the lines under comparison, which would be contrary to fact.

To overcome this difficulty it is necessary that traction on the virtual lines should be independent of the type of tractor on the actual line, and that preferably it should be a type that would be suitable in practice. Then the virtual coefficients assume the character of absolute coefficients.

It is obvious that the virtual line on the level should be worked differently according to the category into which fall the actual lines with which comparison is being made : main lines, light railways, tramways; but it will remain the same for any one category, until sufficient progress in the use of the method permit the model organisation of the traction being compared to be dealt with.

We shall adopt the three-term formula proposed by Professor Tajani (1).

$$S = A + bP + cT \quad \ldots\ldots \quad (2)$$

where :

A, represents the cost per kilometre proportional to the length ;

bP, the costs proportional to the product P, for each kilometre ;

(1) *Trattato moderno di materiale mobile ed esercizio delle ferrovie* (Modern Hand-book of Railway Rolling-Stock and Working), vol. 1, chap. III.

T, the number of train-kilometres run per kilometre of line per annum;

c, the cost per train-kilometre, comprising all costs that vary with the distance run;

S, the cost of working per kilometre.

We shall be able to take account without difficulty, in examining the virtual lengths, of all the costs comprised in cT which include those proportional to the consumption of power.

Assuming a locomotive which can be taken as being the same both on the virtual and actual lines the cost per train-kilometre (the train being made up in each case on the basis of the adhesion available) can be considered as equal in both cases, that is to say, as being independent of the gradient (1) to a close enough degree of approximation for the character of the investigation that we are making. Actually, the locomotive consumes the same amount of energy in both cases, the locomotive crew and the minimum train crew are the same, and the auxiliary staff can also be considered as the same because on steeper gradients it is diminished with the reduction in length of the train, but is increased in density.

With regard to cost of maintenance and renewals, these also are not subject to change so far as they relate to the rolling stock forming the minimum train (locomotive, tender, and van), whereas for the vehicles the reduction in the length of the train due to steeper gradients may be considered as approximately compensated for by the increased wear caused by the use of the brakes.

On the other hand, the gradient has a direct influence on the cost per train-kilometre in so far as it gives rise to changes of speed, not because these changes cause variation in the resistance to traction, but because of the effect they have on the cost of labour, which being paid by time, is affected by the change.

(1) See TAJANI, *loc. cit.*, p. 70, and classification of costs on pp. 72-74.

On these bases, we can imagine that a comparison on the two lines, the virtual and the actual, is made in two steps: in the first place, we can make a comparison between the traction which would be rationally suitable to the gradient i, with that which would be necessary on a corresponding virtual line with locomotives suitable to the gradient i_m of the actual line. According to what we have stated above, the latter traction costs as much per kilometre with the same make-up of train, and at the same speed, as if performed on a line having a constant gradient i_m. This ratio is therefore the same as that which exists between the cost of traction corresponding to the virtual line and that of traction corresponding to the line i_m, each having the appropriate speed which we will call α_m.

In the second place, we can make a comparison between the cost of traction on the line i_m with that of the same trains running over the actual line having a mean gradient i, the make-up of the train remaining the same and the speed varying if necessary: let β_i be this ratio.

In determining next the ratio γ_i between the numbers of trains that can run over the two lines and in multiplying this by the product of the two ratios found above, we obtain the desired virtual coefficient:

$$\lambda'_i = \alpha_m \beta_i \gamma_i \quad \ldots \ldots \ldots \quad (3)$$

3. — *Ratio* α_m. — Let P_{ao} and P_{am} be the adhesive weights and V_o and V_m the speeds of the two locomotives. For different trains running over the same virtual line, it may be assumed that almost the whole of the cost per train-kilometre is proportional to the adhesive weight of the locomotive. It is in direct ratio to this latter that the weight of the train, varies actually, and also consequently the work done, the extra staff carried on the train, as well as the cost of rolling stock, maintenance, and renewals; the only exception is the cost of the locomotive crew and the minimum train crew, which vary in inverse ratio to the time occupied. The

ratio α_m will then take the form :

$$\alpha_m = \frac{a P_{am} + m \frac{1}{V_m}}{a P_{ao} + m \frac{1}{V_o}} \quad \ldots \ldots \quad (4)$$

The two costs can frequently be determined by direct analysis, as also can their ratio α_m. The coefficients a and m, can be determined once for all, and quickly, and the equation (4) may serve to determine α_m approximately, also without analysing the costs of running the train on the gradient i_m. From what we have said above, it is indifferent whether we consider the train that is suited to the gradient i_m or that which with the same locomotive is suited to the gradient i_o and runs at the same speed, because the cost is the same in both cases.

Ratio β_i. — If it is a question of the same train that runs at one time over the gradient i and at another over the gradient i_m the cost of motive power will vary as the resistance per unit, which will change from $w_m + i_m$ to $w_i + i$. For its part, the cost of the crew will vary approximately inversely as the speed, which changes from V_m to V_i. The cost of rolling stock, maintenance, and renewals and other minor expenses, depending on the length of the train (heating, lighting, etc.), will be constant. The ratio will consequently have the form :

$$\beta_i = \frac{p + q(w_i + i) + r \frac{1}{V_i}}{p + q(w_m + i_m) + r \frac{1}{V_m}} \quad \ldots \quad (5)$$

Ratio γ_i. — Let N_o and N_i be the numbers of trains passing over the virtual and actual lines, each hauled by appropriate locomotives: Let Q_o and Q_i be the weights of the two trains hauled available for transport; and let

$$\delta_o = \frac{P_{ao}}{P_{io}} \quad \text{and} \quad \delta_m = \frac{P_{am}}{P_{im}}$$

the two ratios between the adhesive weight and the total weight of the two locomotives, the latter comprising the service wagons, in other words, P_{io} and P_{im} representing the minimum weights of the two trains.

The weights of the two trains on the gradients i_o and i_m will be respectively :

$$Q_o + \frac{1}{\delta_o} P_{ao} \quad \text{and} \quad Q_m + \frac{1}{\delta_m} P_{am}.$$

For adhesion, it will be necessary in both cases to have :

$$Q_o w''_o + \frac{1}{\delta_o} P_{ao} w'_o = 1\,000 f P_{ao}, \quad (6)$$

$$Q_m (w''_m + i_m) + \frac{1}{\delta_m} P_{am} (w'_m + i_m) = 1\,000 f P_{am},$$

where f is the coefficient of adhesion, w''_o and w''_m are the resistances per unit weight on the straight and on the level (at the two speeds V_o and V_m) of the trains, and w'_o and w'_m of the two rakes of vehicles. We find for the two cases :

$$Q_o = P_{ao} \frac{1\,000 f \delta_o - w'_o}{\delta_o w''_o}$$

and $$Q_m = P_{am} \frac{1\,000 f \delta_m - (w'_m + i_m)}{\delta_m (w''_m + i_m)}.$$

The numbers of trains for the same transport, are inversely proportional to the load Q :

$$\gamma_i = \frac{N_m}{N_o} = \frac{Q_o}{Q_m} =$$

$$= \frac{P_{ao}}{P_{am}} \cdot \frac{1\,000 f - \frac{w'_m}{\delta_o}}{1\,000 f - \frac{w'_m + i_m}{\delta_m}} \cdot \frac{w''_m + i_m}{w''_o} \quad (7)$$

Virtual coefficient λ'_i. — The ratio of the virtual coefficients $\frac{\lambda'_i}{\lambda_o}$ is the product of the three ratios α_m, β_i and γ_i given by the formulæ, (4). (5). (7). Putting $\lambda_o = 1$ we have :

$$\lambda'_i = \alpha_m \beta_i \gamma_i \quad \ldots \ldots \quad (3)$$

We will note that if it were supposed that :

$$\alpha_m = 1,\ \beta_i = \frac{w_i + i}{w_m + i_m};$$

$$\delta_o = \delta_m,\ w'_o = w''_o = w_o,\ w'_m = w''_m = w_m,$$

the equation (3) would become identical with that of Maffezzoli, as would be expected.

The virtual coefficients of equation (3) assume an absolute character because they compare traction actually suited to the actual line which is to be investigated, with the constant traction which would rationally be required for the virtual line.

We have already said that the ratio α_m will often be obtained by direct examination, which can be effected by means of equation (4). The same may be said with regard to the ratio β_i which can generally be found from the ratio of the cost of the whole train on the gradient i_m and running on the line that has a mean gradient i with that of the same train on the gradient i_m.

Equation (5) may serve as an auxiliary method, but the determination of these costs by direct analysis, when it is a question of actual trains exactly as they are run in practice, is easy and certain. In general, moreover, for a well laid-out line, the difference between i_m and i will not be very great, because were it so, the line could be split up into several sections for load, each of which would give rise to a different virtual coefficient. It would therefore often be possible to make $V_i = V_m$ in equation (5), and to give to β_i the form :

$$\frac{p' + q(w_i + i)}{p' + q(w_m + i_m)} \quad . \quad . \quad . \quad (5')$$

which is a more convenient form.

Equation (7), which lends itself to rapid calculation, involves elements which are all known.

We should note that in equation (5), the coefficients w_i and w_m are mean coefficients for whole trains given by :

$$w_i = \frac{w'_i + w''_i \delta_o \dfrac{Q_o}{P_{ao}}}{1 + \dfrac{Q_o}{P_{ao}}}$$

and

$$w_m = \frac{w'_m + w''_m \delta_m \dfrac{Q_m}{P_{am}}}{1 + \dfrac{Q_m}{P_{am}}} \quad . \quad . \quad . \quad (8)$$

The distinction between w' and w'' on the various gradients is necessary, because the unit resistances of the minimum train and of the useful part of the train differ greatly amongst themselves, and because the different make-up of the train causes an appreciable variation in the mean resistance.

For the same reason, it is necessary to make the distinction in equations (6) and (7).

In general, it would also be erroneous to assume that $\delta_o = \delta_m$ when the question involves entirely different locomotives.

Substituting (7) in (3) we have :

$$\lambda'_i = \alpha_m \beta_i \cdot \frac{P_{ao}}{P_{am}} \cdot \frac{1\,000 f - \dfrac{w'_o}{\delta_o}}{1\,000 f - \dfrac{w'_m + i_m}{\delta_m}} \cdot \frac{w''_m + i_m}{w''_o} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

4. — We will now consider the return journey of the trains on the down-grade; these will naturally give rise to another virtual coefficient λ''_i, which, provided the traffic is equal in both directions, is symmetrical to the first. This hypothesis is nearly always admissible, because the rolling stock and the crews must always return, and, as Tajani has noted (in the work quoted), the costs do not vary with the extent to which the trains are filled. On the actual line, therefore, they are the same trains and the same locomotives that make the return journey, whereas on the virtual line, on the level, the traction is identical to that of the outward journey.

All this, of course, within the limits of a good approximation.

In the equation (4), the weights P_{am} and P_{ao} and the coefficient m are the same as on the outward journey. For the coefficient a we must substitute the coefficient a' which is the same as a less the energy saved. When the down gradient slightly exceeds 4 per mil, the consumption of power is reduced to that necessary for maintaining steam on the locomotive for the operation of the brakes, for losses, etc. (it is usual to estimate this consumption at one-fifth of that used on the level), so that it may be considered as a known quantity. The speed may be variable. Hence equation (4) becomes :

$$\alpha'_m = \frac{a'P_{am} + m\dfrac{1}{V'_m}}{aP_{ao} + m\dfrac{1}{V_o}} \quad \ldots \quad (10)$$

an equation which can often be obtained by direct comparison of the cost of running the two trains.

As the consumption of power is constant, if the cost is represented by q' we have :

$$\beta'_i = \frac{p + q' + r\dfrac{1}{V'_i}}{p + q' + r\dfrac{1}{V'_m}} \quad \ldots \quad (11)$$

and if the difference between i_m and i is not great, so that we may take $V'i = V'_m$ we get :

$$\beta'_i = 1. \quad \ldots \quad (11')$$

The ratio γ_i of the numbers of trains does not change ; consequently :

$$\lambda''_i = \alpha'_m \beta'_i \gamma_i \quad \ldots \quad (12)$$

We have therefore

$$\lambda_i = \frac{\lambda'_i + \lambda''_i}{2} = \lambda_i \frac{\alpha_m\beta_i + \alpha'_m\beta'_i}{2} \quad (13)$$

and, substituting the values in equation (9) :

$$\lambda_i = \frac{\alpha_m\beta_i + \alpha'_m\beta'_i}{2} \cdot \frac{P_{ao}}{P_{am}} \cdot \frac{1\,000\,f - \dfrac{w'_o}{\delta_o}}{1\,000\,f - \dfrac{w'_m + i_m}{\delta_m}} \cdot \frac{w''_m + i_m}{w''_o} \quad \ldots \quad (14)$$

For each category of trains (for example, express trains and slow trains, and, if desired, for each of the two cases : passenger trains and goods trains) the virtual coefficient λ_i will be found : the mean appropriately obtained for these coefficients taken on the basis of the whole of the traffic to which they refer. will give the virtual index for the line under investigation.

5. — Returning to the equation with three terms :

$$S = A + bP + cT \quad \ldots \quad (2)$$

we may now consider how to extend the scope of the virtual coefficient by considering the two first terms A and bP of the costs of working.

Another important factor may also be brought into the comparison, that is, for the commercial value of the line in question : we are here speaking of the cost of construction; the total annual charge under this head may be taken as being proportional to the length L_i and is consequently capable of being expressed by :

$$\rho C_i L_i$$

where ρ is the rate of interest on the mean capital expended in first cost C_i for the length of track L_i.

On the virtual line of a length $L_o = \lambda_i L_i$, this annual cost will be :

$$\rho C_o L_i \lambda_i,$$

where C_o represents the cost per kilometre of the typical line on the level.

The costs of working comprised in the term A are those which are proportional to the length of the line and which for equal product depend on the gradient,

because on a line with heavier grades the stations, and all the services relating to them, are spaced closer together; moreover the portion of the cost of maintenance which does not depend on the frequency of the train service, and the possible expenditure arising from uncontrollable causes, are generally greater than on lines having small gradients.

If, therefore, on the actual line, we assume an expenditure per kilometre of A_i it will be necessary to consider an expenditure A_o on the virtual line, generally smaller than A_i, and we shall have for the respective lengths :

$$A_i \quad L_i \quad \text{et} \quad A_o \lambda_i L_i.$$

The next term to be considered is that comprising the costs of working in bP. As the product per kilometre must naturally be taken as being the same on the actual line as on the virtual line, and the gradient does not appreciably affect the value of b these expenses will be respectively on the two lines :

$$b\mathrm{P}L_i \quad \text{et} \quad b\mathrm{P}\lambda_i L_i.$$

We now come to the term cT. The coefficient c, the cost per train-kilometre on the virtual line, which we will represent by c_o will become on the actual line, according to what has been stated under the headings 3 and 4 :

$$c_o \frac{\alpha_m \beta_i + \alpha'_m \beta'_i}{2}.$$

The number of trains, which is N_o on the virtual line, becomes :

$$N_o \gamma_i.$$

The two costs (on the virtual and on the actual lines) that are combined in the third term of the equation (2) are therefore :

on the virtual line :

$$c_o N_o \lambda_i L_i,$$

on the actual line :

$$c_o N_o \frac{\alpha_m \beta_i + \alpha'_m \beta'_i}{2} \gamma_i L_i.$$

To sum up, the total of the costs of working and the annual charge due to the cost of construction, are on the virtual line :

$$\lambda_i L_i (\rho C_o + A_o + b\mathrm{P} + c_o N_o)$$

and on the actual line :

$$L_i \left(\rho C_i + A_i + b\mathrm{P} + c_o N_o \frac{\alpha_m \beta_i + \alpha'_m \beta'_i}{2} \gamma_i \right).$$

In order that these two amounts may be equal, it is necessary that :

$$\lambda_i = \frac{A + b\mathrm{P} + \rho C_i + c_o N_o \frac{\alpha_m \beta_i + \alpha'_m \beta'_i}{2} \cdot \gamma_i}{A_o + b\mathrm{P} + c_o N_o} \qquad (15)$$

which is also a virtual coefficient as understood in the larger sense, as a coefficient for the equivalence between the virtual line and the actual line from the point of view of the total cost of working and of the annual charge, which appears in the railway balance sheet under the head of establishment charges.

On the virtual line, once the selection has been made of the suitable locomotives, the product P and the number N_o of trains may be regarded as dependent upon each other.

It is necessary, therefore, to group the lines according to their product per kilometre; in each group the denominator of equation (15) may be considered as constant and it serves in making the comparison between all the actual lines in this group.

MISCELLANEOUS INFORMATION.

[313 .385 (.5)]

1. — The world's railways during the years 1922 and 1923.

COUNTRIES.	Mileage open on 31 December		For each country.		Mileage open at the end of 1923	
	1922	1923	Area (square miles).	Population.	per 100 square miles.	per 10 000 inhabitants.
I. — EUROPE.						
Germany.	Miles.		Round figures.		Miles.	
Prussia (including the Saarre)	21 119.5	21 119.5	113 750	36 691 000	18.5	5.8
Bavaria	5 402.3	5 427.2	29 500	7 140 000	18.3	7.6
Saxony	2 003.9	2 003.9	5 790	4 663 000	34.6	4.3
Wurtemberg	1 391.9	1 393.8	7 530	2 519 000	18.5	5.5
Baden	1 504.4	1 505.6	5 830	2 208 000	25.7	6.8
Other German States	4 401.9	4 367.7	19 850	6 632 000	22.0	6.6
Total for Germany.	35 823.9	35 817.7	182 250	59 853 000	19.6	6.0
Austria	3 938.9	4 153.3	32 350	6 536 000	12.9	6.3
Czechoslovakia	8 718.0	8 718.0	54 210	13 613 000	16.1	6.4
Hungary	5 921.2	5 921.1	35 790	8 119 000	16.4	7.3
Great Britain	24 396.7	24 396.7	94 990	44 517 000	25.7	5.5
France	33 281.8	33 281.8	212 750	39 210 000	15.6	8.5
Russia	30 800.7	35 027.3	1 444 460	67 336 000	2.4	5.2
Finland	2 665.7	2 728.5	150 000	3 365 000	1.8	8.1
Poland	9 871.9	11 974.7	149 930	27 193 000	8.0	0.4
Lithuania	1 938.7	1 938.7	21 350	2 035 000	9.0	9.5
Lettonia	1 770.3	1 754.8	25 410	1 596 000	6.9	11.0
Esthonia	890.4	890.4	18 340	1 107 000	4.8	8.0
Italy	12 500.9	12 840.2	119 660	38 756 000	10.8	3.3
Belgium	6 893.0	6 893.0	11 740	7 666 000	58.7	9.0
Luxemburg	334.3	334.3	1 000	261 000	33.3	12.8
Holland	2 140.7	2 140.7	13 210	6 865 000	16.3	3.1
Switzerland	3 323.1	3 571.7	15 950	3 902 000	22.5	9.1
Spain	9 643.9	9 676.1	195 140	21 658 000	5.0	4.5
Portugal	2 129.4	2 129.5	35 480	6 033 000	6.0	3.5
Denmark	3 086.4	3 086.4	16 600	3 381 000	18.5	9.1
Norway	2 140.7	2 147.5	125 030	2 650 000	1.8	8.1
Sweden	9 436.3	9 555.6	173 170	6 006 000	5.5	15.9
Yougoslavia	5 699.3	5 699.3	96 140	12 017 000	6.0	4.7
Roumania	7 325.4	7 322.4	113 900	16 500 000	6.4	4.4
Greece	1 983.5	1 983.5	50 200	5 065 000	4.0	3.9
Albany	40.4	186.4	14 520	877 000	1.3	2.1
Bulgaria	1 624.3	1 624.3	39 810	5 008 000	4.0	3.2
Turkey in Europe	257.3	257.3	1 160	1 000 000	22.2	2.57
Malta, Jersey, Isle of Man	68.4	68.4	430	375 000	16 1	1.9
Total for Europe.	228 645.5	236 119.6	3 444 970	412 500 000	6.9	5.7

COUNTRIES.	Mileage open on 31 December		For each country		Mileage open at the end of 1923	
	1922	1923	Area (square miles).	Population.	per 100 square miles.	per 10 000 inhabitants.
II. — AMERICA.	Miles.		Round figures.		Miles.	
Canada	39 541.0	39 861.7	3 729 880	8 788 000	1.1	45.4
United States of America (including Alaska)	252 241.3	251 162.6	3 625 240	106 139 000	6.9	23.7
Newfounland	950.7	952.6	162 940	263 000	0.6	36.2
Mexico	16 443.0	16 443 0	760 340	14 235 000	2.1	11.6
CENTRAL AMERICA :						
Guatemala	613.3	681.0	42 360	2 005 000	1.6	3.4
Honduras	559.2	811.5	38 680	673 000	2.1	12.1
Salvador	256.0	256.0	13 170	1 582 000	1.9	1.6
Nicaragua	200.0	200.1	49 230	638 000	0.3	3.1
Costa-Rica	545.5	667.4	23 010	498 000	2.9	13.4
Panama	297.6	469.1	32 400	434 000	1.5	10.8
GREATER ANTILLES :						
Cuba	3 005.0	3 722.7	44 210	3 123 000	8.4	11.9
Dominican Republic	408.2	408.3	19 340	895 000	2.1	4.5
Haïti	167.1	173.4	11 080	2 045 000	1.6	0.9
Jamaica	198.8	200.1	4 210	858 000	2.1	2.3
Porto-Rico	339.9	339.9	3 440	1 365 000	9.8	2.5
LESSER ANTILLES :						
Martinique	139.1	185.2	390	244 000	48.0	7.6
Barbadoes	497.7	497.8	160	156 000	3.2	3.2
Trinity	108.1	173.4	1 970	366 000	8.9	4.7
United States of Columbia	925.8	1 020.3	495 390	5 855 000	0.16	1.7
Venezuela	659.9	659.9	393 990	2 491 000	0.16	2.7
British Guiana	103.7	103.8	89 500	298 000	0.16	3.5
Dutch Guiana	37.2	37.3	54 330	111 000	0.06	3.4
Ecuador	651.8	651.8	118 540	2 000 000	0.5	3.2
Peru	1 988.4	2 075.5	532 220	5 550 000	0.32	3.7
Bolivia	1 502.5	1 502.5	567 670	2 890 000	0.32	5.2
Brazil	18 704.2	18 704.2	3 281 020	30 636 000	0.5	6.1
Paraguay	308.8	308.8	171 820	1 000 000	0.16	3.1
Uruguay	1 652.8	1 652.9	72 160	1 603 000	2.3	10.3
Chili	5 301.0	5 049.9	289 820	3 755 000	1.8	13.4
Argentine Republic	23 156.4	23 156.3	1 153 170	9 548 000	1.9	24.2
Total for America.	371 505.0	372 128.9	15 781 680	210 044 000	2.4	17.7
III. — ASIA.						
Central Russia and Siberia	6 656.2	7 083.8	6 363 070	97 857 000	0.11	0.7
China	6 837.6	7 173.2	4 301 130	440 139 000	0.16	0.2
Japan, including Corea, Formosa and Kwantung	12 284.1	13 109.9	265 150	77 728 000	5.0	1.7
British India	40 491.1	40 491.1	1 828 570	318 942 000	2.3	1.2
Ceylon	731.9	732.6	25 330	4 505 000	2.9	1.6
Persia	350.4	350.5	628 210	10 000 000	0.05	0.4
Asia Minor, Syria, Arabia with Cyprus	3 828.9	3 828.9	1 418 280	21 311 000	0.32	1.8

COUNTRIES.	Mileage open on 31 December		For each country.		Mileage open at the end of 1923	
	1922	1923	Area (square miles).	Population.	per 100 square miles.	per 10 000 inhabitants.
	Miles.		Round figures.		Miles.	
Palestine	...	695.9	9 000	757 000	7.7	9 2
Portuguese Indies	54.0	54.0	1 470	579 000	3.7	0.9
Malay States	1 163.2	1 163.2	52 090	2 448 000	2.3	4.7
Dutch Indies (Java, Sumatra)	1 882.1	1 894.6	733 700	49 351 000	0.32	0.4
Siam	1 422.9	1 538.6	195 060	9 207 000	0.8	1.7
Cochinchina, Camboja, Annam, Tonkin	1 490.0	1 490.1	274 450	19 122 000	0.5	0.7
Pondicherry	59 0	59.0	120	172 000	51.0	3.4
Philippine Islands	890 6	809.7	115 020	10 953 000	0.6	0.7
Total for Asia	77 961.6	80 475.1	16 210 650	1 063 071 000	0.5	0 7
IV. — AFRICA.						
Egypt, including Sudan	4 894.0	4 894.0	1 364 920	19 629 000	0.32	2 5
Algiers and Tunis	4 219.8	4 219.8	270 510	7 896 000	1.6	5.3
Marocco	861.9	884.9	162 170	5 480 000	0.5	1.6
Belgian Congo	1 263.3	1 273.2	979 540	7 153 000	0.16	1 8
South African Union	11 475.7	11 570.1	473 110	6 929 000	2.4	1.7
Colonies.						
ENGLAND :						
British East Africa (including Zanzibar)	851.3	1 083.7	431 990	5 945 000	0.32	1.8
Ex-German East Africa (Tanganyka)	891.7	891.7	365 110	4 107 000	0.32	2.2
Rhodesia	2 457.6	2 457.6	440 020	1 883 000	0.5	13.0
Betchuanaland	425.1	425.1	275 070	153 000	0.16	27.8
British Central Africa (Nyassaland)	173.9	173.9	39 960	1 202 000	0.5	1.4
Sierra-Leone	334.9	338.0	24 900	1 541 000	1.3	2.2
Gold Coast	193.9	193.9	80 270	2 078 000	0.32	0.9
Nigeria	1 125.9	1 125.9	336 190	18 750 000	0.32	0.6
Mauritius	133.6	144.2	730	377 000	19.6	3.9
South West Africa	1 307.4	1 413.6	322 450	228 000	0.5	62.0
FRANCE :						
French Sudan	1 713.8	1 713.8	356 580	2 475 000	0.5	6.9
Togo	203.2	204.5	20 080	670 000	1.0	3.0
Cameroun	192.6	246.7	166 530	3 000 000	0.16	0.8
French Somali Coast (Abyssinia)	495.2	495.2	46 330	65 000	1.1	76.2
French equatorial Africa	1 542.9	1 542.9	871 040	2 851 000	0.16	5.4
Madagascar	402 0	435.6	223 950	3 278 000	0.16	1.3
Reunion	78.9	78.9	930	173 000	8.5	4.5
PORTUGAL :						
Angola	818.3	818.3	484 880	4 182 000	0.16	1.9
Mozambique	454.8	454.8	293 450	3 120 000	0.16	1.4
Total for Africa	36 511.7	37 080.3	8 030 710	103 165 000	0.5	3.6

COUNTRIES.	Mileage open on 31 December		For each country.		Mileage open at the end of 1923	
	1922	1923	Area (square miles).	Population.	per 100 square miles.	per 10 000 inhabitants.
V. — AUSTRALIA.	Miles.		Round figures.		Miles.	
New Zealand	3 011.2	3 029.3	104 750	1 219 000	2.9	24.9
Victoria	4 349.1	4 377.0	878 800	1 531 000	5.0	28.6
New South Wales	5 443.9	5 477.5	309 470	2 100 000	1.8	26.1
South Australia	3 467.3	3 488.4	380 090	495 000	1.0	70.5
Queensland	7 022.9	7 067.0	670 530	756 000	1.1	93.5
Tasmania	867.5	873.1	26 220	214 000	3.4	40.8
West Australia	4 839.3	4 869.8	975 950	333 000	0.5	146.2
North Territory	197.6	198.8	523 650	3 867 000	0.032	0.5
Territory of the Federal Capital	4.9	4.9	930	2 572 000	0.5	0.018
Hawaï (with the Isles Maui and Oahu)	242.9	242.9	6 450	256 000	3.7	9.5
Total for Australia.	29 446.6	29 628.7	3 876 840	13 343 000	1.0	22 2
RECAPITULATION.						
Europe	228 645.5	236 119.6	3 444 970	412 500 000	6.9	5.7
America	371 505.0	372 128.9	15 781 680	210 044 000	2.4	17.7
Asia	77 961.6	80 475.1	16 210 650	1 063 071 000	0.5	0.7
Africa	36 511.7	37 080.3	8 030 710	103 165 000	0.5	3.6
Australia	29 446.6	29 628.7	3 876 810	13 343 000	1.0	22.2
Total for the world.	744 070.4	755 432.6	47 344 850	1 802 123 000	1.6	4.2

[621 .132.5 (.73]

2. — New American three-cylinder locomotives.

Fig. 1, p. 367.

For some time passed, American locomotive builders and railway companies have been interesting themselves in three-cylinder locomotives.

In addition to the more even turning moment and the better use of the adhesion obtained thereby, these engines, in which the work is divided up between three cylinders, may be built to a capacity which it would be difficult to obtain with the ordinary two-cylinder arrangement.

It is no doubt considerations of this and a similar nature which have justified the construction of the two new types of three-cylinder locomotives, a description of which we take from the *Railway Age*.

This describes sixteen engines built for the Southern Pacific, and one for the Union Pacific by the American Locomotive Company, in both cases being of the 4-10-2 type.

The first mentioned are stated to be the most powerful locomotives in existence other than the articulated type. They are used for passenger and freight traffic in the mountainous districts of Sierra Nevada where the gradients are as much as 1 in 45. The adhesive weight is 316 000 lb., and the tractive effort at 70 % cut-off is 83 500. The wheels

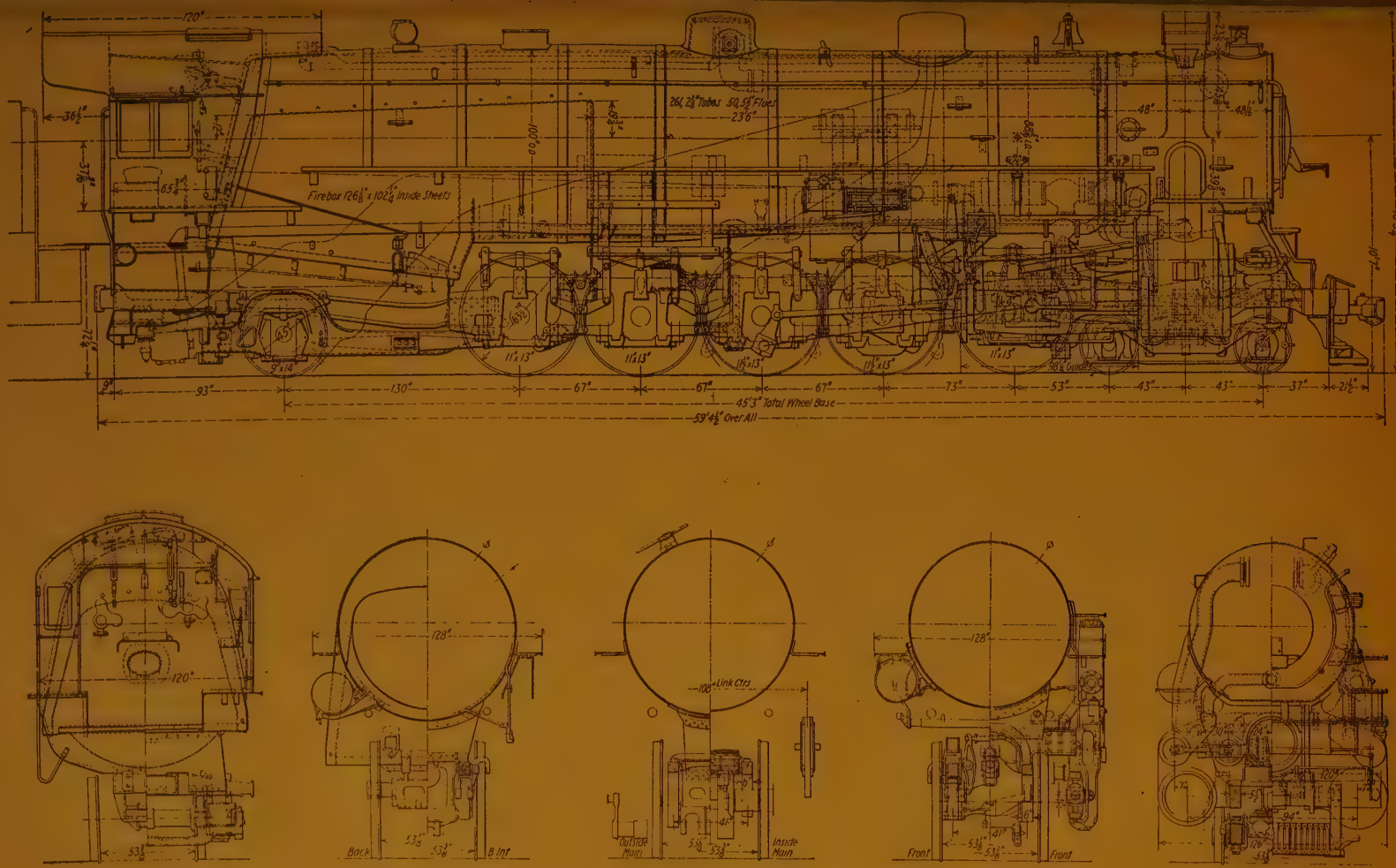


Fig. 1. — Elevation and cross sections of the 4-10-2 type Southern Pacific locomotive.

of the trailing truck may be driven by a *booster* which increases the tractive effort to 95 700 lb.

The Union Pacific locomotive has an adhesive weight of 288 500 lb., and with a cut-off of 85 % develops a tractive effort of 78 000 lb.

The Southern Pacific engines are oil fired, while the Union Pacific engine is fired with coal by means of an « Elvin » mechanical stoker.

The boilers have the usual features of those used on powerful American locomotives : a spreading grate, a round top box sloping towards the rear, combustion chamber and partially conical barrel. The diameter in the case of the Southern Pacific engines is 8 ft. 4 in. at the largest diameter, and 7 ft. 4-5/16 in. at the front ring.

The outside cylinders which drive the third pair of coupled wheels are horizontal. The inside cylinder which drives on to the second pair of wheels is inclined, but its piston valve is in line with those of the outside cylinders, which allows it to be driven through suitable rocking levers from the outside sets of motion, which are of the Walschaerts type.

The tenders, which have a cylindrical tank, are carried on cast steel frames mounted on two six-wheeled bogies.

The diagram which we give refers to the Southern Pacific locomotives.

The principal dimensions of these two types are given in the following table.

	Southern Pacific.	*Union Pacific.*
Cylinders, diameter and stroke	2 — 25 in. by 32 in. 1 — 25 in. by 28 in.	2 — 25 in. by 30 in. 1 — 25 in. by 28 in.
Piston valves, diameter	11 inches.	11 inches.
Working pressure	225 lb.	210 lb.
Grate area	89.6 sq. ft.	84 sq. ft.
Heating surface	5 676 sq. ft.	5 522 sq. ft.
Superheater heating surface	1 500 sq. ft.	1 505 sq. ft.
Diameter of driving wheels	63 1/2 inches.	63 inches.
Tractive effort (85 %)	...	78 000 lb.
Tractive effort (70 %)	83 500 lb.	...
Adhesive weight	316 000 lb.	288 500 lb.
Total weight	442 000 lb.	405 000 lb.
Weight of tender	244 000 lb.	242 500 lb.
Wheel base of coupled wheels	22 ft. 10 in.	22 ft. 6 in.
Rigid wheel base	16 ft. 9 in.	16 ft. 6 in.
Wheel base of engine and tender	87 ft. 3 1/4 in.	82 ft. 5 in.
Coefficient of adhesion	3.61	3.69

E. M.

[621 .94 (42)]

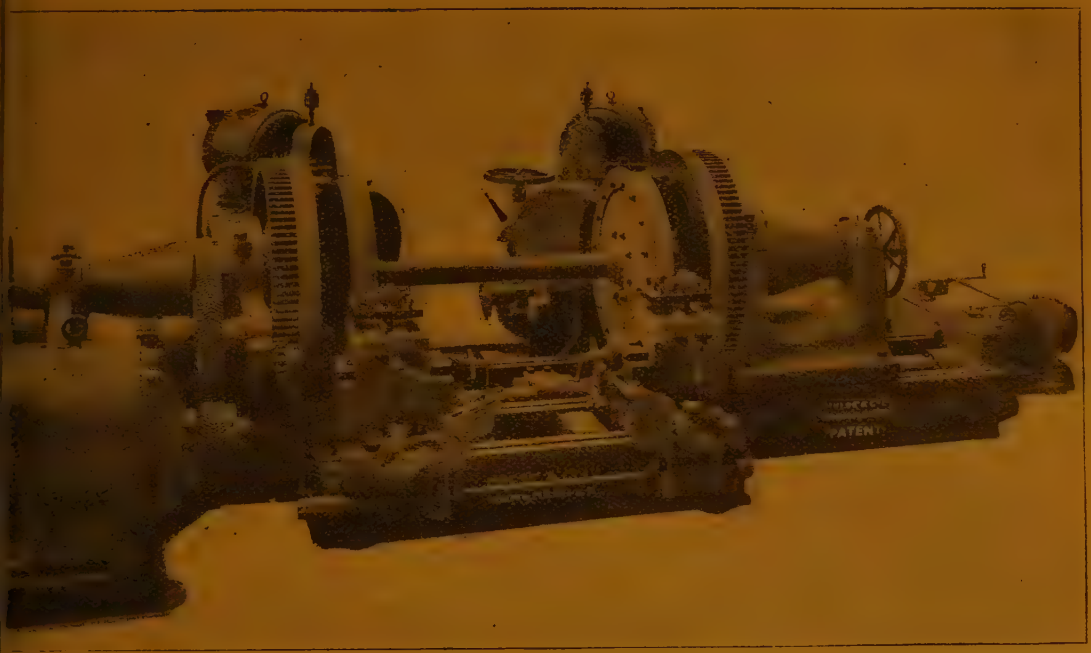
3. — A new wheel lathe for carriage and wagon shops.

Figs. 2 to 5, pp. 369 and 370.

(*The Railway Engineer.*)

There has been a tendency to treat the turning of different classes of wheels as though the conditions were similar, and in consequence of this, wheel lathes for railway coaching stock have generally increased in power and weight in the same ratio as locomotive wheel lathes.

The condition of locomotive and railway-carriage wheels when brought in for re-turning are essentially different, as deep cuts are often necessary on locomotive wheels either to reform the flange or to bring the wheel diameter to that of others coupled to it. In general,



2. — Hulse combined turning and grinding machine for railway rolling stock wheels. View from cutting side.

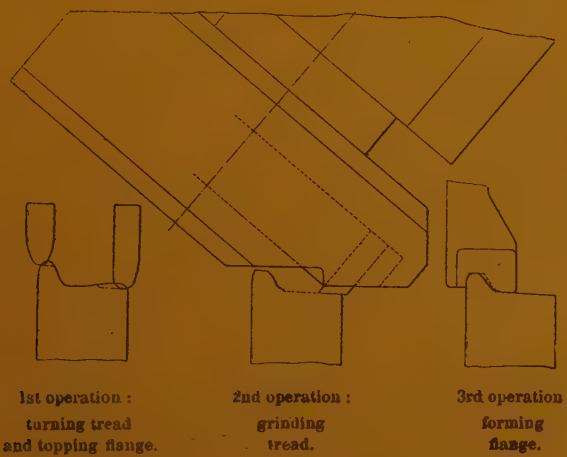


Fig. 3. — Turning and grinding operations on worn wheels.

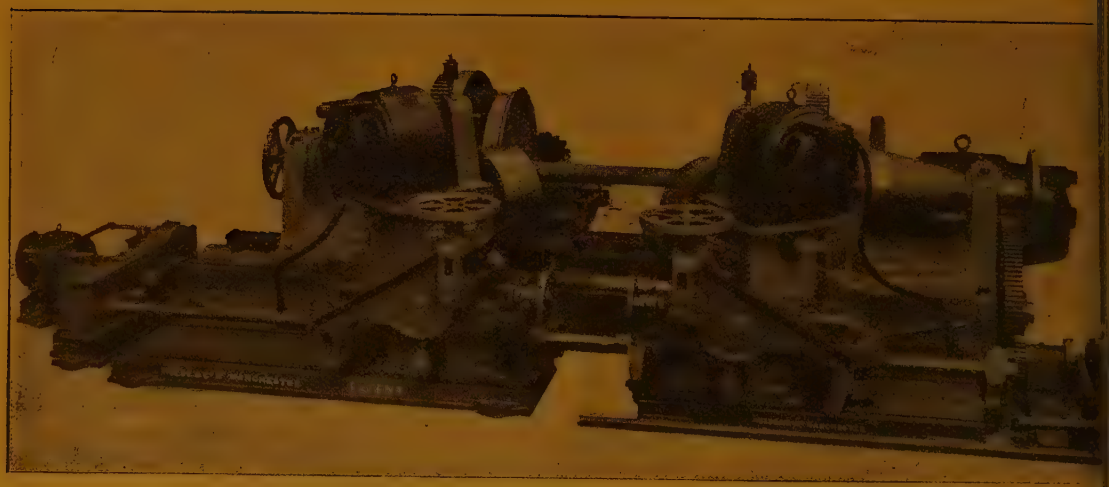


Fig. 4. — View from grinding side, showing self-contained heads.

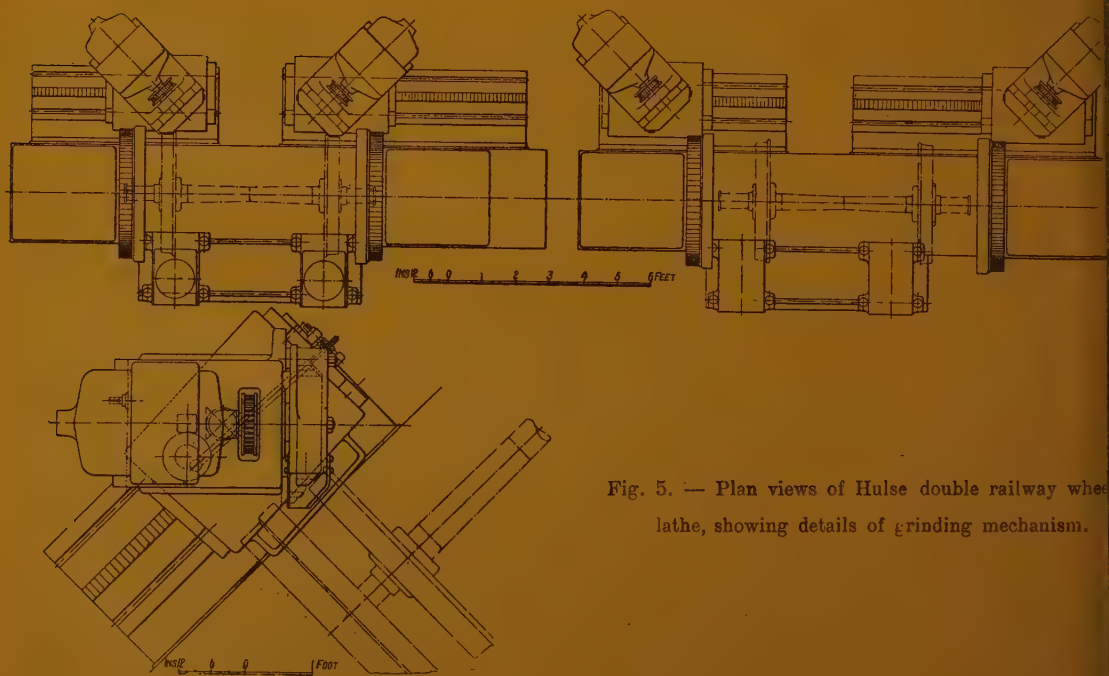


Fig. 5. — Plan views of Hulse double railway whee
lathe, showing details of grinding mechanism.

there is little flange deformation in carriage wheels which is due to wear, but in many cases flats often form on the circumference of the tread and hard spots are present as the result of skidding. These cannot be turned through, and the common practice is to take a cut deep enough to get well under them. This is more than the amount necessary to re-form the flange, and thus there is a great wastage of tyre steel.

Records recently taken in a British railway shop, using a softer steel than is usual in current practice, showed the following results : — Out of 186 pairs of wheels a second cut, approximately 1/8 inch deep, was necessary in 43 cases, in order to get below the hard places. This 1/8 inch of metal represents one-tenth of the working life of the tyre, and, incidentally, one-tenth of its value. The percentage of cases wherein extra metal has to be removed, due to hard spots, is greater where steel of higher tensile is used. It is to obviate this wastage of material, that the grinding-wheel lathe, illustrated herewith, has been introduced. It consists essentially of two headstocks each with suitable drivers for driving the wheels, two tool rests, and two self-contained grinding heads.

Each tool-rest of the lathe is fitted with a gauging device and four tools — one for the tread, another for topping the flange, a forming tool for the flange, and a tool for the chamfer. These tools are set to determined positions by a gauge.

By means of the gauging device, the operator can find the lowest point of wear on each wheel, *i. e.*, the maximum diameter up to which it is possible to clean both wheels. A cut is started on the treads and on the flange simultaneously, and, due to the indexed rule on the tool slide and the tool being set to the gauge, it is ensured that both wheels are similar in diameter. The tread on the outside is slightly humped up for about 1 inch, partly owing to rolling of the metal, and it is possible to turn this before encountering the hard places, and when they are reached the turning is stopped. It is possible, of course, to omit this turning, but generally it is the more economical method.

The remainder of the tread is ground, and it is possible, due to this method, to just clean up the wheels, leaving a semblance of the previous outline. After the grinding is completed on the tread the flange is finished with the former tool.

As has been stated, the advantage of this system is that the metal removed is reduced to a minimum, and it is possible to insist on a resemblance of the old form being left somewhere on the surface. As to the actual saving effected by this method, the results quoted above show that in approximately 25 % of the tyres machined one-tenth of the total life and value of the tyres is saved at each machining.

Another factor of value is the saving in tool steel, the cost of which in breakage and re-grinding, when dealing with hard tyres, is considerable. The time in dealing with a hard tyre in the new lathe is less than in the ordinary lathe.

Wagon wheels have not these hard spots due to skidding, and are usually of a lower tensile steel. With the exception of brake-van-stock, therefore, grinding does not offer advantages. The lathe illustrated is capable, however, of a high output when turning wheels only, whether they be carriage wheels without hard spots or wagon wheels.

These lathes are in successful operation in two shops of two of the English railway groups.

[621 .132.5 (.73)]

4. — Boston & Albany Railway Company's 2-8-4 locomotive.

Figs. 6 to 8, pp. 372 to 375.

(From *The Railway Engineer* and *Railway Review*.)

The Boston & Albany Railway Company gave an order to the Lima Locomotive Works, Inc., to build them a 2-8-4 locomotive, which was put into service in February 1925, and

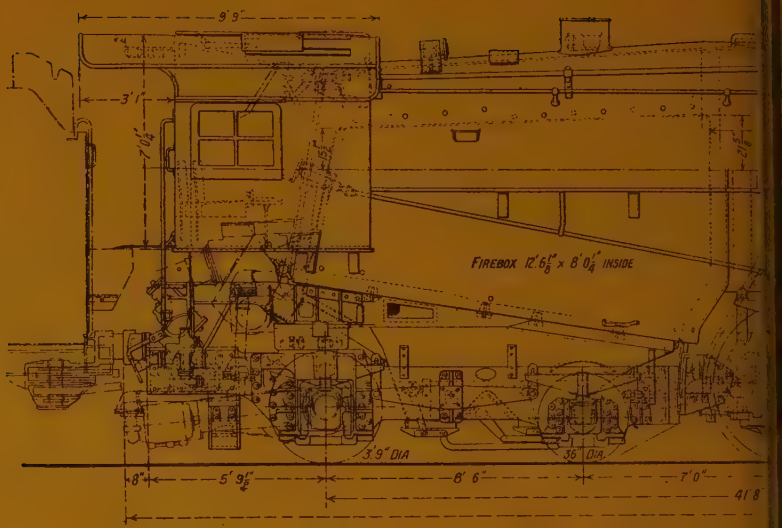


Fig. 6. — 2-8-4 ty

which embodies some remarkable features.

The intention of the designers of this type of engine was to produce a powerful and highly efficient boiler, and with this in view constructed the grate so that the fuel consumption should be low per unit of its area when the locomotive was developing its greatest effort. This consideration induced them to adopt a grate area of 100 square feet.

The distribution of the weight of a firebox made to these exceptional dimensions would be such that a single back carrying axle would be insufficient to deal with the weight limit allowed, so that it was found necessary to replace the single-axled truck with a four-wheeled trailing truck, hence the 2-8-4 arrangement.

The design of the framing is new — the main frame stopping short at the back of the coupled wheels where it is joined up to the framing of the back truck by means of an articulation. It is through this truck that the tractive effort and buffering action are transmitted, and which carries at the back end the coupling arrangement.

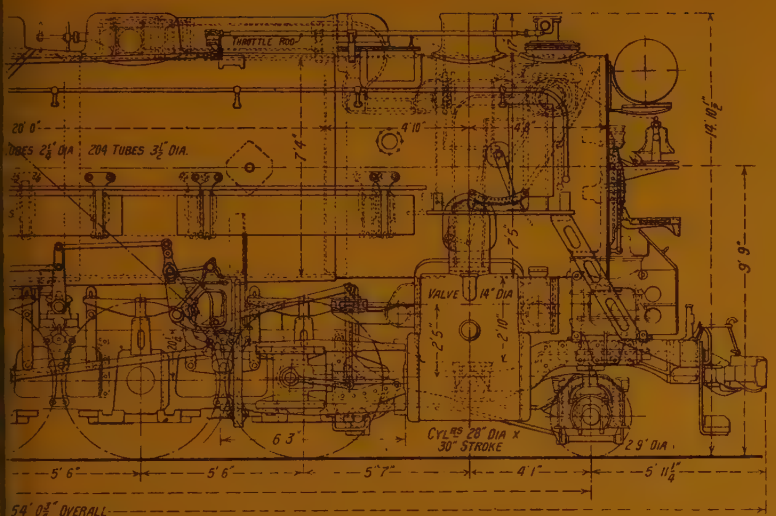
The vertical load is transmitted through four points on the trailing truck; on each side at the front end the extended parts of the main frame are supported; the back corners of the firebox are carried on an automatic centralising arrangement, the result being that the truck can pivot in both directions round its articulation, but its vertical position remains unchanged as far as the main framing is concerned.

Following the usual American practice, the invariable distribution of the weight on the wheels (suspension on three points) has been adopted.

The springs of all four pairs of coupled wheels are equalised to the leading two-wheeled bogie truck, so that the latter and the coupled axles form the points of central suspension.

The two side supports are provided on the trailing truck, the latter being fitted with two equalising levers to balance the weight on the wheels on each side.

The absence of any main framing at the back end has made it easier for the construction of the ashpan. The latter, instead of being fastened to the foundation ring, is carried by the framing of the trailing truck, and the play that is necessary to allow the latter



& Albany Railway.

a certain amount of displacement at the same time allows very wide air passages between the ashpan and the foundation ring. On account of the distance between the axles of the truck, it has been possible to give to the ashpan a very large cubical capacity, amounting to nearly one cubic foot to each square foot of grate area.

The engine is provided with a booster working the back axle of the truck, this axle being fitted with larger diameter wheels than the front axle — 45 inches against 36 inches.

In order to carry the cab, footplate, and other accessory appliances, the foundation ring has been cast with projecting flanges on the back and sides, which are bolted to the brackets.

There are two special points that should be noticed with regard to the motion. First of all, the maximum cut-off is limited to 60 %, and in order to obtain a sufficient average pressure in the cylinders, a maximum boiler pressure of 240 lb. per square inch has been adopted.

This high pressure increases the load on the crank pins and on the driving boxes. The connecting rod is in two parts, the front one acting directly on the main crank pin (third coupled axle), and the other transmits a portion of the thrust on to the back axle, thus lightening the load on the main crank pin by about a quarter.

The arrangement adopted is shown in figure 7, the big end of the connecting rod properly so called is forked, between the cheeks of which the back portion is let in, thus forming a coupling rod. The two parts are assembled together by a strong steel bushing forced by pressure into the cheeks of the fork, thus forming a hinge pin for the back part.

Cast steel instead of cast iron has been used in the construction of the cylinders, which has effected a saving in weight of 4 000 lb., and instead of the exhaust passages being formed entirely in the casting, they are partly made up with outside piping. No other steam passages are in the saddle except those leading to the front and back faces of each semi-saddle towards the interior and the top and leading up to the base of the exhaust pipe.

Like other locomotives with limited admission, the 2-8-4 locomotive of the Boston & Albany Railway is provided, in addition to

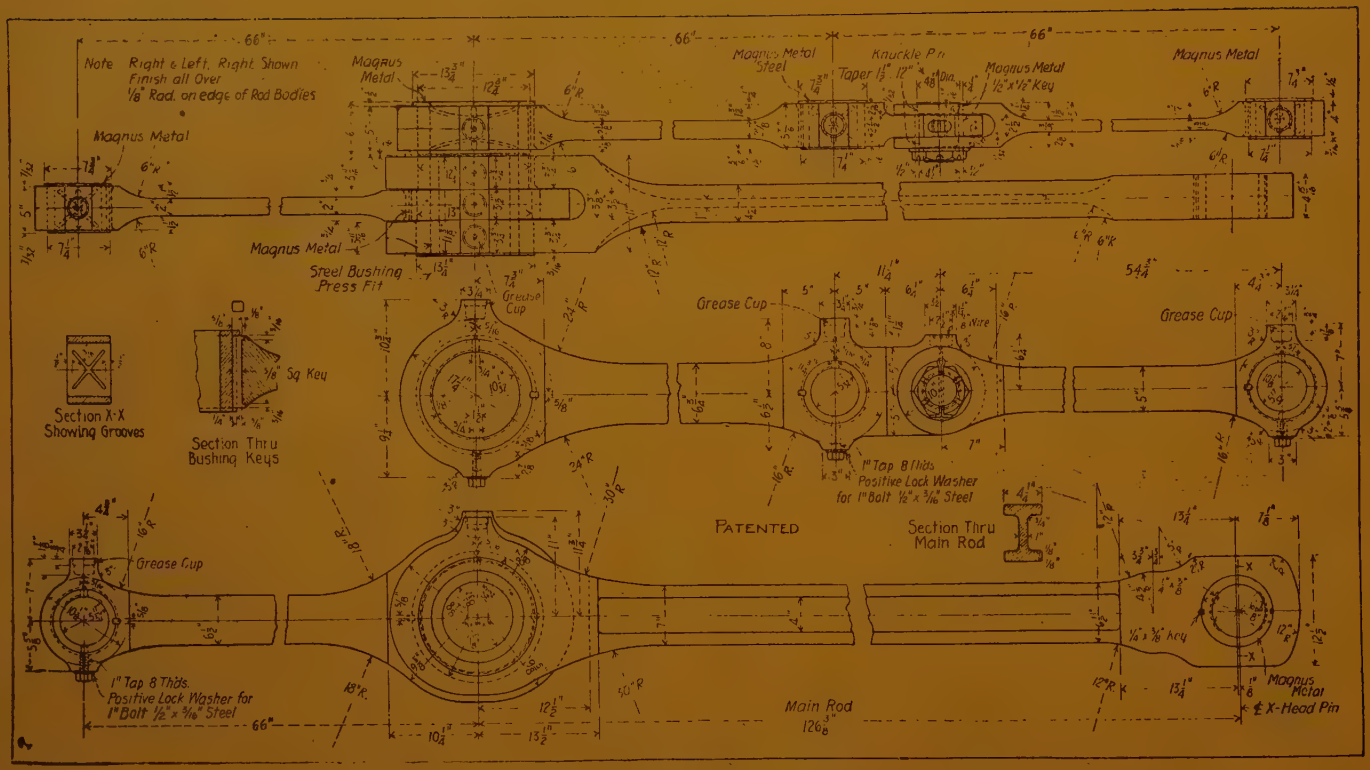

Note Right & Left, Right Shown
Finish all Over
1/8" Rad. on edge of Rod Bodies
Magnus Metal
Steel Bushing Press Fit
Knuckle Pin
Taper 1 3/8" 12" 48 Dia.
Magnus Metal 1/2" x 1/2" Key
Grease Cup
Section X-X Showing Grooves
3/16" Sq Key
Section Thru Bushing Keys
1" Tap 8 Thds. Positive Lock Washer for 1" Bolt 1/2" x 3/16" Steel
PATENTED
Section Thru Main Rod
1/4" x 1/8" Key
Main Rod
Magnus Metal
EX-Head Pin

Fig. 7. — Connecting rod and coupling rod.

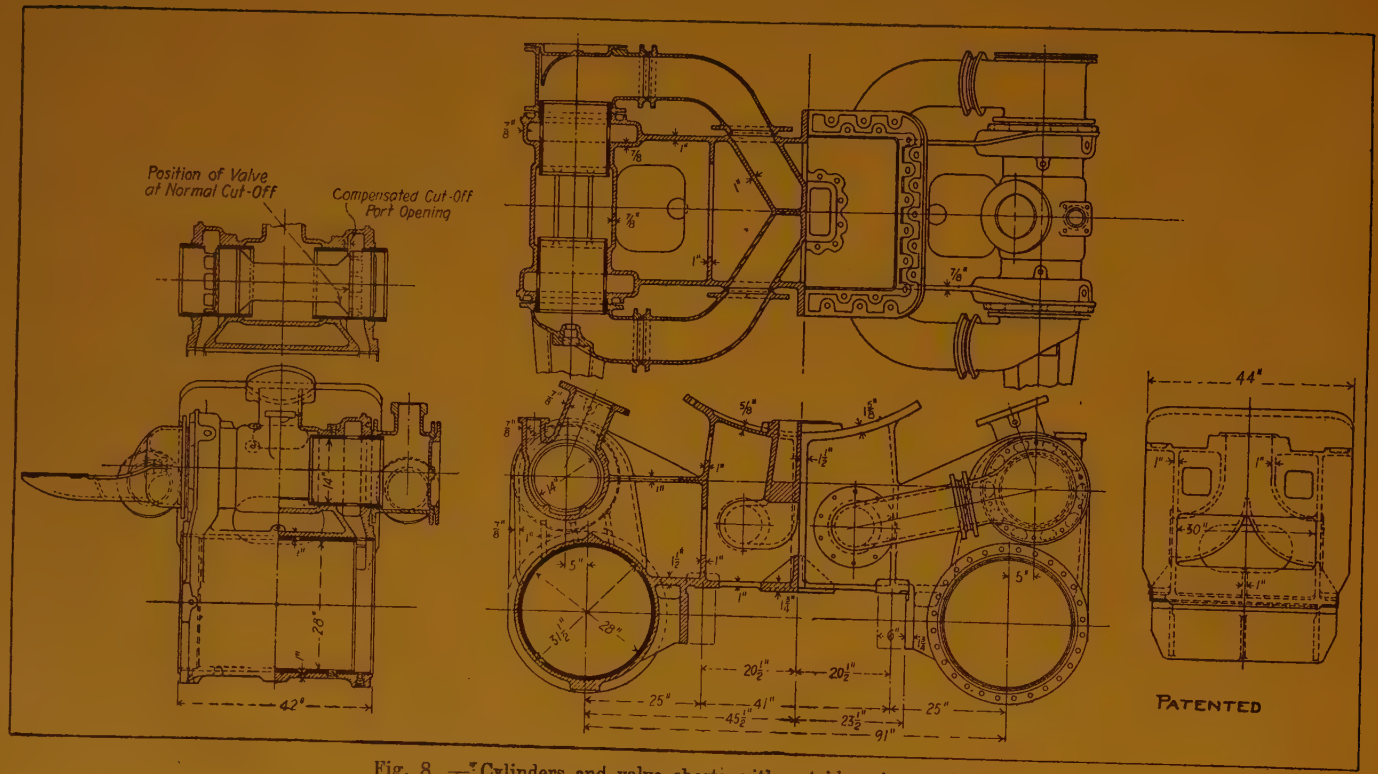


Fig. 8. —Cylinders and valve chests with outside exhaust pipes.

the ordinary admission ports cut in the steam chest sleeves, with a number of supplementary slots of reduced section, which allow starting to take place in any position of the cranks, but become inoperative as soon as the engine has acquired a certain speed.

In addition to this, an arrangement has been provided to extend admission on the front face of the pistons in order to regulate the turning moment. This object is attained in extending by 7/16 inch two of the ordinary admission ports (the others having a width of 2 3/16 inches). By this means the admission on the front face when running slowly is extended to 63 % instead of the 60 % on the back face.

The shape of the boiler is shown in figure 6. The box top is in the form of an arc of large radius sloping towards the back and joined up to sloping sides, thus making room for a grate 96 1/4 inches wide. The brick arch is carried on five water tubes.

An outside steam pipe joins the dome to the superheater header. The throttle arrangement is fixed in the smokebox in front of the chimney. The two steam delivery pipes encircle the inside of the smokebox through which they pass to the admission passages of the cylinders.

The principal dimensions of this engine are as follows :

Diameter of cylinders	28 inches.
Stroke of cylinders	30 —
Adhesive weight in working order	248 200 lb.
Weight in working order on leading truck	35 500 lb.
Weight in working order on trailing truck	101 300 lb.
Weight in working order, total for locomotive	385 000 lb.
Weight in working order, total for tender	275 000 lb.
Wheel base of coupled wheels	16 ft. 6 in.
Wheel base, rigid	16 ft. 6 in.
Wheel base, total for locomotive	41 ft. 8 in.
Wheel base, total for locomotive and tender	82 ft. 6 in.
Diameter of driving wheels	63 inches.
Diameter of leading truck wheels	33 —
Diameter of trailing truck wheels	36 and 45 inches.
Grate area	100 square feet.
Heating surface	5 110 — —
Superheating surface	2 111 — —
Steam pressure	240 lb. per sq. inch.
Rated tractive force	69 400 lb.
Rated tractive force, with booster	82 600 lb.

Capacity of tender :

Water	15 000 gallons.
Coal	18 short tons.

E. M.

[385. (06.111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

Award of the triennial « Arthur Dubois » Prize [1].

(2nd award : 1923-1925.)

The special Committee appointed to examine the papers sent in on operation or construction of railways in connection with the prize instituted by the Permanent Commission to perpetuate the memory of Mr. Arthur Dubois, have unanimously decided that this prize for the second triennial period (1923-1925) should be awarded to Mr. Albert Henrotte, engineer on the Belgian State Railways, for his work on « Turbine locomotives ».

We offer our hearty congratulations to Mr. Henrotte on his success.

The Executive Committee.

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[1] The regulations governing the award of this prize were published in the May 1920 number (p. 310) of the *Bulletin of the International Railway Congress Association*.

OBITUARY

Denis PÉROUSE,

Honorary Inspector General of Bridges and Roads;
Honorary President of the Administrative Council of the Paris, Lyons and Mediterranean Railway;
Former Member of the Permanent Commission of the International Railway Congress Association;
Delegate to the Sessions at London (1895), Paris (1900), Washington (1905), Berne (1910) and Rome (1922).

We were sorry to hear of the death of our former colleague on the Permanent Commission : Mr. Denis Pérouse, Honorary President of the Administrative Council of the Paris, Lyons & Mediterranean Railway.

Mr. Pérouse was nominated a Member of the Permanent Commission in 1900, and acted as such until the Rome Session of 1922. Born in 1846, Mr. Pérouse entered in 1866 the « Ecole Polytechnique » and in 1868 that of the Bridges and Roads Service. His studies were interrupted by the War of 1870 in which he served as an Artillery Officer.

He resumed his studies after the Campaign and passed out in 1871 with the Diploma of Engineer of Bridges and Roads.

At the commencement of his career he was given control of a department of a railway at Valence. In 1876 he was attached to the Operating Headquarters of the Northern Railway at Paris.

As Chief Engineer he returned to Valence, but was recalled to Paris in 1885 to take up duty as Engineer-in-Chief controlling the operating of the Paris, Lyons & Mediterranean System. He displayed such remarkable technical and administrative ability that he was called to the Control of Railways at the Ministry of Public Works, first of all as Assistant and then as Director.

In the interval he was made Secretary of the Committee on the Technical Operation of the Railways, delegate to the Consulting Committee, member and reporter of numerous technical commissions, etc. He carried out these duties until 1906 when he took a well merited rest. A new period of active life however opened out for him. Many important French Companies interested in the Transport Industry sought him out in his retirement, and asked him to put at their service his experience and ability.

In this way he became in 1910 Admi-

nistrator, and in 1915 Vice-President of the Paris, Lyons & Mediterranean Railway. He was also appointed Administrator of the Moroccan Railways of the Franco Spanish Railway from Tangiers to Fez, and President or Administrator of other important undertakings.

On 29th October 1925 his Colleagues on the Administrative Council of the Paris, Lyons & Mediterranean Railway, still suffering from the recent loss of their President, Mr. Stephan Dervillé, unanimously suggested him as his successor. Mr. Pérouse, who felt his strength failing, declined this honour, whereupon the Council made him Honorary President, this being the last Council meeting he attended.

He died peacefully on the 16th November 1925.

As Director of Railways at the Ministry of Public Works, then as Administrator of the Paris, Lyons & Mediterranean Railway, he was on the Permanent Commission of our Association, and was a delegate to the Sessions of the Congress at London in 1895, at Paris in 1900, at Washington in 1905, at Berne in 1910 and at Rome in 1922.

He took a great interest in the Congress Association with which his work was marked by great clearness of judgment.

We have sent our sincerie condolences to his family and our heartfelt regrets to the Paris, Lyons & Mediterranean Company.

The Executive Committee.

NEW BOOKS AND PUBLICATIONS

[656 .2 (02]

MILLER (S. L.) Ph. D., assistant professor of economics, University of Wisconsin. — **Railway transportation, principles and point of view.** — One volume (8 1/4 × 5 1/2 inches) of XXVII + 905 pages, with 39 tables and 44 figures in the text. — 1924, A. W. Shaw Company, Chicago and New York, and A. W. Shaw & Co. Ltd., London. — Prix : $4.

The author of this book is assistant professor of economics of the University of Wisconsin. The book itself leads one to believe that he is not himself a railway man, and in the preface he speaks of it as an attempt at « the presentation of historical material and in analyses, to judge from a public point of view » and that the « facts have been presented in an impartial manner ». There are, however, few books which have been written on a particular subject that have dealt with that subject in such a lucid and detailed manner. One advisedly says particular subject, for it is only the railway administrations of the United States of America which are dealt with, but nothing could be more complete or more helpful to anyone desiring to study the methods of administration, etc., which differ so much from that of the majority of the countries of the railway world.

In a book of about 900 interesting pages, it is perhaps ungrateful to speak of ommissions or lack of fuller detail, but the great interest it excites in the reader makes one wish for even more particulars of the administrations and work of the organisations set out shortly in a few pages.

The arrangement of the book is excellent; the various items are given under headings in the letter press, as well as in the summary of headings placed at the head of each chapter. At the end of each chapter is a bibliography of all the recent books and papers on the subject the chapter has been dealing with, whilst a comprehensive index completes the volume.

After an introduction dealing with the Nature, Scope, Significance and early history of Transportation, the volume is split up into four parts dealing with four distinct points of administration.

The first of these is on « The American (U. S. A.) Railway Net » dealing with the growth and cause of growth of the railway system of the United States from its inception until the return of the railways to the companies after the war.

The second section deals with « The Railway Service » and includes the administrative organisation, the various services and charges, and railway accounting and statistics. One matter of special interest is the account of the growth and development of the Pulman and the Express Companies and their relations with the railway proper.

The third part is on « The Economics of Railway Enterprise » and is largely financial, and includes interesting chapters on rate making.

The last portion is concerned with « Regulations of the Railways », and not only deals with Federal Regulations generally, but with the Transportation Act of 1920 and the working of the Labour Board. The account of the shopmen's strike is particularly interesting, showing as it does the effect of strong public opinion on labour disputes.

To anyone acquainted with American

nomenclature, the use throughout of the word « railway » in place of « railroad » might at times be somewhat confusing, but it makes the book easier reading for a British railwayman, and many of the latter should read it for the reasons stated in the beginning of this review.

D.

[385. (02]

BOURDE (J.), French Government Engineer of Public Works. — **Manuel des chemins de fer (Railway manual).** — Motive power, rolling stock, traffic working and legislation — One volume 6 1/4 × 4 1/4 inches) of 460 pages with 75 figures in the text — 1924, J. B. Baillière & Sons, 19, rue Hautefeuille, Paris. — Price : 18 francs.

This book is one of the technical series published under the editorship of Mr. René Dhommée, inspector general of Technical Schools. It is intended, as is stated by Mr. Dhommée in the preface, for intelligent workmen who wish to have a reliable guide. Like other books of this kind, it aims at supplying fuller information for workers who are not in a position to appreciate the ordinary text books, and at presenting the information in a clear manner so that they can more easily grasp this and become masters of their crafts.

With this object in view, would it not have been better to have dealt with a more restricted range of railway subjects ? The matters dealt with are very comprehensive and various, and the author has no doubt found it a difficult task to condense these so that they may be presented in a clear manner without exceeding the size of a hand book. It appears that he has accomplished this very successfully, but will he find his readers among intelligent workmen ? No doubt a certain number, of which there are not many and of which it is to be wished that there were more, who desire to extend their outlook, will use Mr. Bourde's book with the object of increasing their knowledge. There they will find in a simple and clear form very valuable and extensive information on the various branches of railway work. We think, however, that this book goes rather too far to meet the requirements or provoke the interest of manual workers who would gain greater advantage from books with a more limited scope dealing more closely with the work which they have to carry out day by day.

Notwithstanding this opinion, we may say that the author has produced a very useful book, and as he has extended its scope, it will appeal to another class of readers. A large number of railway employees are too much specialised with a limited outlook and no experience outside their own duties. A number of employees of this nature will read Mr. Bourde's book with great advantage. They will obtain very concise and useful information on the class of work with which they have to deal themselves, and they will gain a knowledge of the methods of organisation of other branches of the service, thus permitting them to take a more active and consciencious part in the general work of the organisation of which they form elements.

Even a brief description of the work would occupy too much space. We will therefore confine ourselves to an extract from the table of contents.

FIRST PART — **Steam engines.**

Chapter

I. — Properties of steam ;

II. — Employment of steam as a prime mover ;

III. — The locomotive.

SECOND PART. — **Motive power and rolling stock.**

Chapter

IV. — Motive power;
V. — Locomotive calculations;
VI. — Types of locomotives;
VII. — Necessary equipment of the locomotive department;
VIII. — Rolling stock;
IX. — Brakes;
X. — Heating and lighting.

THIRD PART. — **Traffic operation.**

Chapter

XI. — Organisation of stations;
XII. — Traffic working in goods yards and stations;
XIII. — Safety appliances;
XIV. — Telegraphs and telephones;
XV. — Traffic working;
XVI. — Running of trains;
XVII. — Upkeep of the track.

FOURTH PART. — **Commercial operation.**

Chapter

XVIII. — Rates;
XIX. — Passenger traffic;
XX. — Freight traffic;
XXI. — Utilisation of slow freight rolling stock;
XXII — Military transportation;
XXIII. — Working expenses;
XXIV — Statistics.

FIFTH PART. — **Legislation**

We may perhaps be permitted in closing to make one remark. The fifth part, which is very interesting and deals with legislation, would be of more value, especially for French readers, if it included the principal provisions of the Act of 1921, which instituted the new railway regime in France rendering the railways financially sound and creating a bonus system with the object of interesting the staff in the traffic results.

E. M.

[656 .2 (02 (.54)]

GHOSE (S. C.). Late Reader, Postgraduate Teachings in Arts, Calcutta University. — **Freight yards terminals and trains and freight traffic operation**. — One volume (10 × 6 1/2 inches) of 196 pages, with 11 sheets of diagrams at the end. — 1925, The Book Company, 4/4A, College Square, Calcutta.

Were it not for the Introduction, it would be somewhat difficult to ascertain the object of this book. In the Introduction, however, it is stated that the object « has been to collect together all facts relating to goods traffic and transportation in its various stages ». This as far as Indian railways it does probably effectually, but in many parts it is so elementary as to be of no value to the practical railwayman, whilst in others it is somewhat disjointed and ill arranged when dealing with more technical matters. The readers will probably comprise Indian students who propose to enter the railway service.

On the whole, however, the book is interesting as being written by an old Indian railway official, who has evidently read considerable literature on railways dealing with British and American practice.

By far the largest section of the book is the first, which deals with « Goods trains and goods yards and their operation ». Many authors are quoted, and it is interesting to see that these include Mr. Simon-Thomas, whose report at the recent London Congress is mentioned.

« Push and Pull » yards are apparently largely used in India.

At the end of the section there are a

series of statistics showing the work done and the cost of nearly 60 yards in India, nine of which are « Gravity and Hump yards ». The largest is at Naihati on the Eastern Bengal, which in October 1924 dealt with 61 500 wagons. The work done in each of the months of September, October and November 1924 is dealt with, but it would have been more interesting if months at the different parts of the year had been selected.

Other sections deal with procedure in goods operation, pooling and distribution of wagons and coal traffic. In connection with this latter, it is interesting to note that in 1923-1924 the East Indian Railway dealt with 10 610 000 tons of coal in the year.

The book concludes with sections on conveyance of live stock, goods operating statistics, loss and damage of goods and with railway arrangements at Delhi, which is becoming the great railway centre of India.

D.

[625 .13 (02]

ROUSSELET (Louis), engineer A. and M., and PETITET (Aimé), engineer A. and M. — **Stabilité des infrastructures et ouvrages d'art en maçonnerie (Strength of masonry structures and buildings).** — Volume I : General. — Theoretical study. — Appendix. — 1 vol. in-8° (10 1/4 × 7 3/4 inches) 403 pages with 219 figures in the text. — 1924, Ch. Béranger's Technical Library, Paris and Liége.

« The object of this book is to simplify the calculation of strength and stability of masonry structures and buildings. »

The examples dealt with in this book are innumerable.

They deal especially with foundations on level and sloping ground.

The walls of water reservoirs and retaining walls, earth retaining dams, abutments and the piers of flat and arched bridges.

The sills, piers and lateral walls of locks and sluice gates.

The anchorage of cables and pylons for suspension bridges.

The foundations of swing-bridges.

Large diameter conduits frequently buried, and tunnels.

In this group, numerous practical cases of sea walls, quay walls and dams have been set out at length.

The construction of large diameter counduits built for making use of waterfalls in mountainous countries is also explained in detail.

The appendix contains many useful suggestions with regard to public works, such as the digging of tunnels under rivers, etc.

This book, being written in a practical manner, should be consulted with benefit by those engaged on public works, they will find in it valuable information resulting from long experience of working out schemes rapidly.

R. D.